Ecology, Uses, and Management of Pinyon-Juniper Woodlands

Proceedings of the Workshop

March 24-25, 1977
Albuquerque, New Mexico

Rocky Mountain Forest and
Range Experiment Station
Forest Service
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Abstract

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It is estimated the pinyon-juniper woodland type occupies 33 million acres in the western United States. This vast resource has great potential for social benefits. Our knowledge of the type is summarized in 12 papers in three areas: Ecology of the type, uses and potentials, and management strategies for the woodland zone.

Keywords: Pinyon-juniper, forest utilization

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Earl F. Aldon and Thomas J. Loring
Technical Coordinators

Sponsored by:

Society of American Foresters—Southwestern Section

New Mexico Department of State Forestry

Region 3 and Rocky Mountain Forest and Range Experiment Station,
Forest Service, U.S. Department of Agriculture

Foreword

With the recognition that pinyon-juniper woodlands occupy 33 million acres in the Southwest, it became obvious to the sponsors of the workshop that knowledge and understanding of management needs and opportunities were lacking to properly handle this vast resource.

As a first step toward filling this need, the Southwest Section of the Society of American Foresters, Region 3 of the U. S. Forest Service, the Rocky Mountain Forest and Range Experiment Station, and the New Mexico Dept. of State Forestry brought together these participants to discuss in depth the ecology and management possibilities of the Southwest pinyon-juniper woodlands.

These papers, ranging from general topics dealing with multiple benefits to very specific papers dealing with procedures for inventories, illustrate the wide range of subject matter presented at this workshop. An obvious omission was the water and sediment yields generated from the type. However, this topic is broad enough to merit a workshop of its own.

The Coordinators commend the participants and thank the sponsors for what may well become a landmark workshop in the management and utilization of the Southwest woodland type. We thank the authors for their efforts; articles are published verbatim in this report in the interest of timeliness.

Earl F. Aldon
Thomas J. Loring
Technical Coordinators

The Workshop
March 24-25, 1977

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The Southwestern Pinyon-Juniper Ecosystem

Rex D. Pieper [1/]

The pinyon-juniper vegetational type represents a resource which has been neglected in the past, but which has received a considerable amount of attention recently. Evidence of the increased interest in the pinyon-juniper type is the review by Springfield (1976), the Symposium at Utah State University (Gifford and Busby 1975) and the bibliography by Aldon and Springfield (1973).

The main purpose of this paper is to set the stage for other papers in the program. The presentation will be largely descriptive and will not include information on ecosystem functioning.

DISTRIBUTION AND AREA

The pinyon-juniper type is widely distributed in the Southwest as shown in maps presented by Aldon and Springfield (1973) and Clary (1975). Table 1 shows that New Mexico has the largest area of pinyon-juniper vegetation among the four southwestern states of Arizona, Colorado, Nevada, and New Mexico. Colorado has the smallest area with only 9.0 percent of the state covered by pinyon-juniper vegetation. In New Mexico some of the trees are scattered, and there's always a problem drawing lines around types.

Elevationally, pinyon-juniper stands occur in the foothills above desert or grassland vegetation but below ponderosa pine forests. In the Southwest elevations range from about 5000 ft. to over 7500 ft.

Table 1.--Area occupied by pinyon-juniper vegetation in the southwest (from West. et al. 1975).

State	Square Miles	Percent of State
Arizona	19,695	17.3
Colorado	9,367	9.0
Nevada	20,520	18.6
New Mexico	32,199	26.5

1/ Professor of Range Science, New Mexico State University, Las Cruces, New Mexico.

CLIMATE

Climatic patterns vary considerably within the pinyon-juniper type (Table 2). In some areas such as those in Northern Arizona and Southern Utah, precipitation is mainly winter-spring while further south it comes mostly during the summer. Temperatures also vary considerably, and with precipitation distribution, form several distinct patterns shown in Table 2. Precipitation totals are lower in this type than in forest types at higher elevations.

Table 2.--Climatic characteristics of southwestern, pinyon-juniper vegetation types. (From Springfield 1976).

Climate	Precipitation (means) Winter	Summer
Cool, moist	10	8
Warm, moist	11	7
Cool, winter dry	6	8
Warm, winter dry	6	10
Cold, winter dry	5	9
Cold, summer dry	8	5
Warm, summer dry	8	5

SOIL

Soils also vary considerably over the range of the pinyon-juniper type. Three characteristics have been identified with pinyon-juniper soils:

1. Shallow
2. Rocky
3. Low in fertility

Of course, there are many soils under pinyon-juniper stands which do not fit these characteristics. Pinyon-juniper soils have developed from a wide range of parent materials in the Southwest (Springfield 1967):

Sandstones
Limestones (Dolomites)
Shales
Basalt (Gem-Springerville)
Granite.

It's not surprising that soils would be variable with these parent materials and climates throughout the range of pinyon-juniper.

OVERSTORY VEGETATION

In the Southwest the main species of the juniper component are as follows:

Utah juniper - *Juniperus oteosperma*
Rocky mountain juniper - *J. scopulorum*
One-seed juniper - *J. monosperma*
Alligator juniper - *J. deppeana*.

Rocky mountain juniper is the most widely distributed species, occurring throughout the West from British Columbia to New Mexico (Little 1971). Utah juniper is widely distributed in Utah, Northern Arizona, and some of the surrounding states. One-seed juniper is widespread in New Mexico and Arizona where it is often the dominant tree. Alligator juniper is abundant in Western New Mexico and Arizona, although it also occurs in other areas. The maps of Little (1971) are excellent sources of distributional data on these species.

The pinyon component is composed of these species:

Pinyon pine - *Pinus edulis*
Single leaf pinyon - *P. monophylla*
Mexican pinyon - *P. cembroides*.

Mexican pinyon is found largely in southern Arizona and northern Mexico. The center of distribution of pinyon pine is Nevada. Singleleaf pinyon is widely distributed in Utah, Colorado, Arizona and New Mexico (fig. 1). Apparently there are some hybrids between the two species (Lanner 1975). However, even though there is some gene exchange between these two populations, they remain reasonably distinct and Lanner (1975) recommended the recognition of the two species. Table 3 shows overstory composition of several pinyon-juniper stands in the Southwest.

The pines tend to increase in abundance as elevations increase while the junipers decrease (fig. 2).

SHRUBBY COMPONENTS

Shrubby species are often codominant with the trees in many of these stands. Table 4 lists some of the important shrubs in different areas. The northern region refers to northern Arizona and New Mexico; the southwestern region refers to southwestern New Mexico and southern Arizona; and the southeastern region refers to central and southeastern New Mexico. Big sagebrush is a common component in the north. In western New Mexico several species of oak are important and they become more important in northern Chihuahua, Mexico. In central Chihuahua, the junipers and pinyons fade out and the vegetation becomes an oak woodland (Perez, unpublished). In central New Mexico, wavyloaf oak (*Quercus undulata*) forms dense stands and often is an understory to pinyon-juniper. Other important species are listed in Table 4.

Herbaceous understory species also vary considerably among pinyon-juniper stands. Table 5 shows some of the most important herbaceous species in different regions. These are some of the most important species but there are many more species which are listed by West (1975).

Many studies have shown that there is an inverse relation between density of trees and herbaceous vegetation (Figure 3). Apparently reduced light intensity is a major factor in pinyon-juniper stands influencing herbage yields.

Pinyon-juniper vegetation is a major natural resource in the southwestern U.S. As the other papers in this symposium will illustrate, this vegetation type is worthy of study and intensive management.

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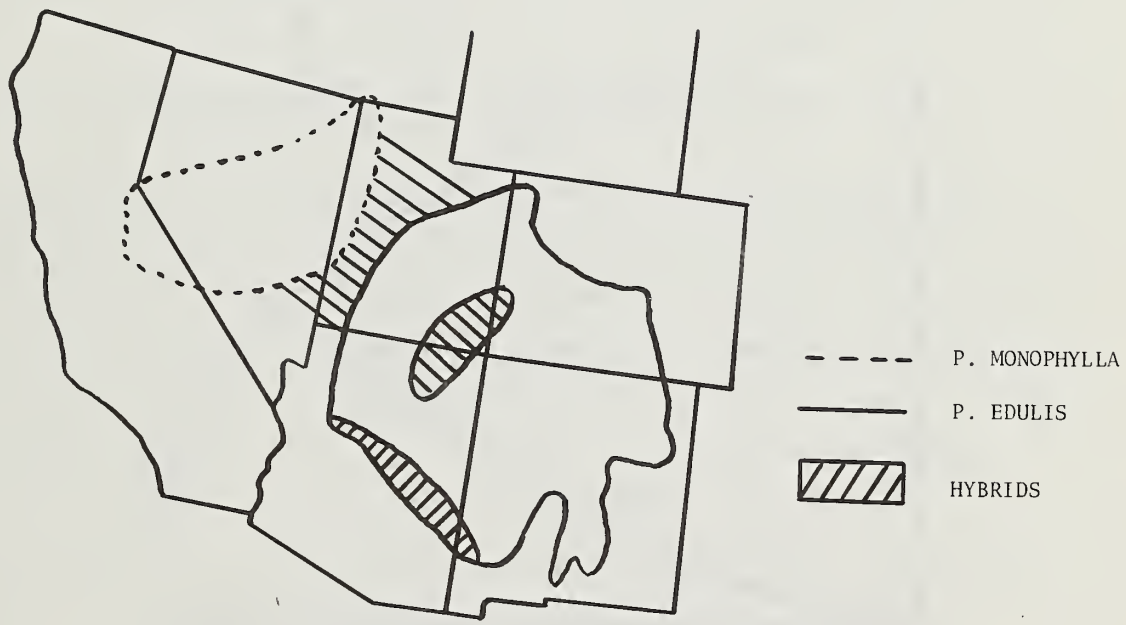

Figure 1. Distribution of pinyon pines (Adapted from Lanner 1975).

Table 3. Composition of overstory vegetation in different areas.

Location	Pinyon pine	Mexican pinyon	Utah Juniper	One-Seed juniper	Alligator juniper
Southern Utah[1]	35		10		
Northern Arizona[2]	30		29		
Southern Arizona[3]		5			67
South-central N.M.[4]	28			9	63
S.E. New Mexico[5]				19	50

[1]From Mason et al. 1967.

[2]From Jameson et al. 1962.

[3]From Whittaker and Niering 1965.

[4]From Lymbery and Pieper, unpublished data.

[5]From Gehlbach 1967.

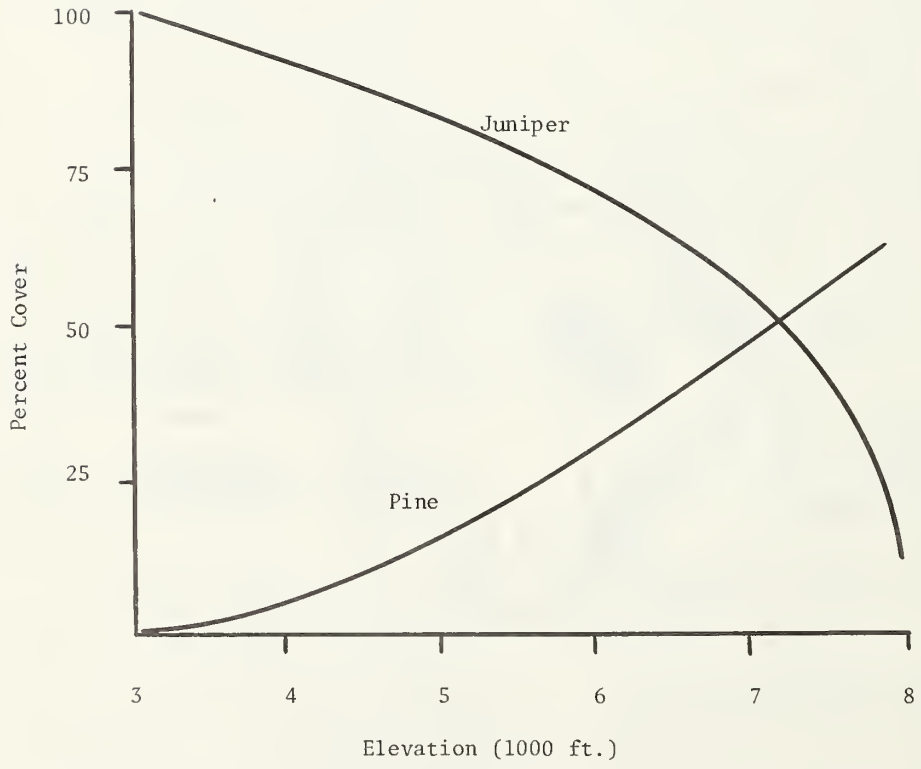

Figure 2. Change of pinyon-juniper cover with elevation. (From Woodin and Lindsey 1954).

Table 4. Important shrubby species in various pinyon-juniper stands in the Southwest.

Northern Region[1]	Southwest Region[2]	Southeast Region[3]
Artemisia tridentata	Quercus arizonica	Quercus undulata
Purshia tridentata	Quercus emoryi	Opuntia imbricata
Xanthocephalum sarothrae	Quercus grisea	Rhus trilobata
Quercus gambelii	Quercus oblongifolia	Dasylirion leiophyllum
Opuntia spp.	Nolina microcarpa	

[1]From Jameson et al. 1962; Thatcher & Hart 1974.

[2]From Whittaker and Niering 1965.

[3]From Gehlbach 1967; Lymbery and Pieper, unpublished data.

Table 5. Important herbaceous species in the understory of pinyon-juniper from different areas.

Northern Region	Southwestern Region	Southeastern Region
Poa longiligula	Muhlenbergia emersleyi	Bouteloua gracilis
Oryzopsis hymenoides	Piptochaetium fimbriatum	Muhlenbergia pauciflora
Stipa speliosa	Eragrostis erosa	Stipa neomexicana
Bouteloua gracilis		Lycurus phleoides
Hilaria jamesii		Aristida spp.

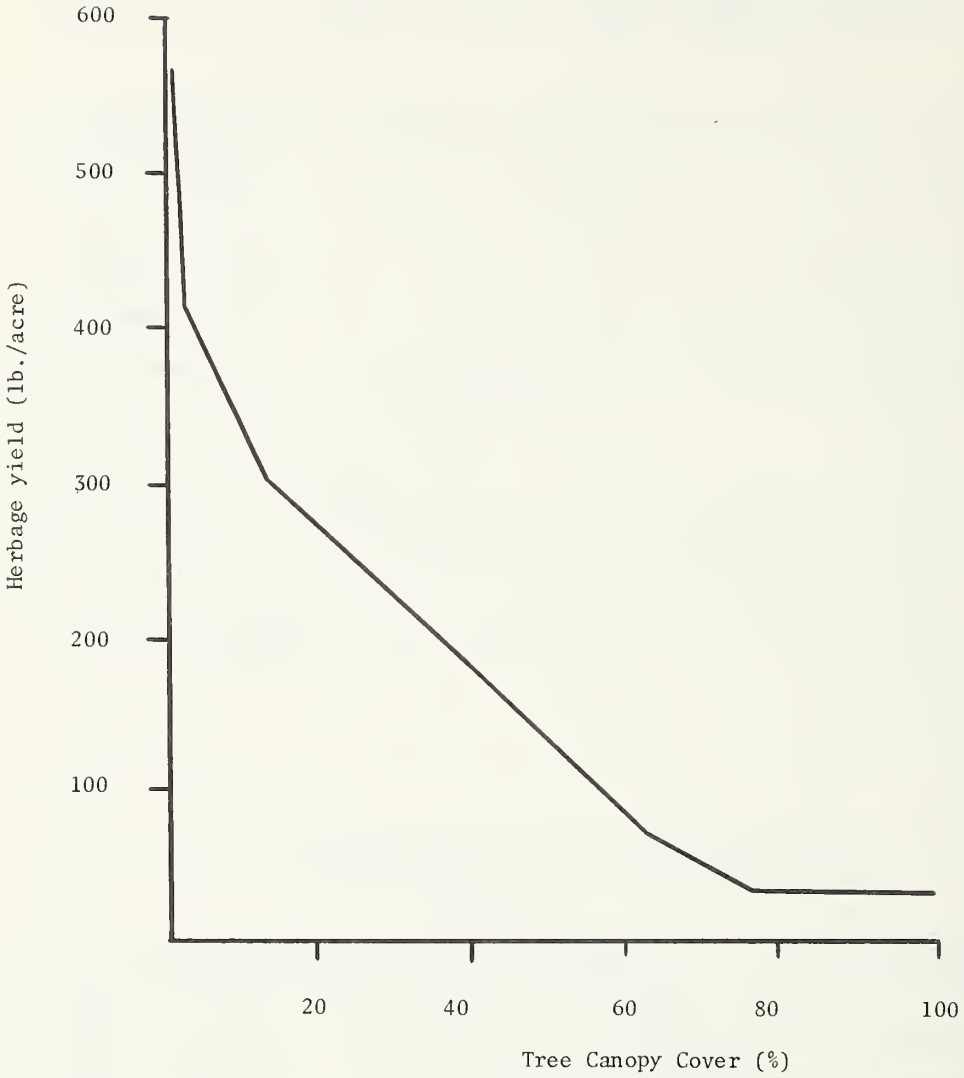

Figure 3. Relation of herbage production to pinyon-juniper canopy cover. (From Arnold, Jameson and Reid 1964).

Pinyon and Juniper Inventory Procedures

Gary W. Clendenen 1/

I appreciate the opportunity to participate in this discussion of pinyon-juniper management. The P-J type occupies a significant area: about 32 percent of the forest land in the Rocky Mountains. Our Renewable Resources Evaluation Work Unit, which has timber inventory and assessment responsibilities in the Rocky Mountain States has been concerned about this type for years. But because its forest product values have been low until recently, we called it noncommercial forest land.

Our interest in the type goes beyond its timber values. We are asking questions about the land and how it is used. Fifteen years ago, my project, in cooperation with range management specialists in the Station and Intermountain Region, proposed to develop inventory techniques for pinyon-juniper land. That proposal included measurements for wood volume and descriptions of understory vegetation and land attributes. Unfortunately, the proposal died from lack of funding. About the same time, some photo volume estimating techniques were developed, but from a very limited data source. To date, our estimates of the P-J resource have been based on these aerial photo techniques. Our estimates of P-J type area are pretty good, but we have little to no information about volumes and land attributes.

Today, we find ourselves in a somewhat different ball game. Interest in the P-J resource is increasing rapidly. I have seen reports of increasing demands for P-J products. Interest in the land for grazing, wildlife habitat, recreation, and watershed values has increased markedly over the last decade.

The first opportunity for our project to become involved in detail in the P-J type came with a request from the Carson National Forest here in New Mexico for assistance in conducting an inventory to develop estimates of the forest product potential of pinyon and juniper land. This request fortunately coincided with an opportunity my project had to acquire some additional money. It also coincided with the Station's opportunity to expand work in the type at our Reno field unit for the study of pinyon-juniper ecology and management. My project is coordinating closely with the Reno effort. The work I'm going to talk about was carried out in cooperation with the Carson National Forest and the Southwestern Region. This work had two primary objectives:

1. As previously mentioned, it was to provide the Forest with information on pinyon-juniper forest product potential;
2. It was to develop a more useful approach to estimating usable wood volume in pinyon-juniper trees.

Every Forester worth his salt knows that diameter at breast height and tree height are required to estimate the volume of wood in trees. It is rather obvious however, when you look at a pinyon or juniper tree that this approach may not be too useful. Almost immediately, the question arises: "Which D.B.H. do we measure?" However, almost every study I have seen on volumes for pinyon and juniper trees has taken this D.B.H.-height approach. With the Carson, we took a different approach altogether. We took the liberty of discarding D.B.H., and adding such measurements as basal diameter and number of stems (Fig. 1 and Fig. 2). I am presently completing the analysis of the data and testing the equations. I can't give a specific volume estimating equation today, but I will give you some of my preliminary findings:

1. Basal diameter is a better volume predictor than D.B.H.
2. Total height is a volume predictor.
3. Number of stems is a volume predictor.

The Reno project is trying to develop estimates of P-J biomass and they are using a similar approach to ours on the Carson. I will be using some of their data to test my results.

When I have completed the analysis, the results will be published. Two publications are planned, and they should be available by the end of the year. These publications will be:

1. Volume Equations and Tables.
2. Inventory Field Procedures for the P-J Type.

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Research in the Pinyon-Juniper Woodland

Elbert L. Little, Jr. [1]

The aims of this article are to review some early research work in the pinyon-juniper woodland in the Southwest and to make suggestions for future research. This vast vegetation type occupies many million acres across several States. It should be managed under multiple use and sustained yield to be more productive and to become a greater source of employment and income for local residents. The high acreage compensates for low unit productivity.

A research project on the pinyon-juniper woodland was begun in 1937 by the former Southwestern Forest and Range Experiment Station, of the Forest Service, United States Department of Agriculture, with headquarters at Tucson, Arizona. I was assigned to that project from September 1937 to December 1941 as assistant forest ecologist (later as associate) to work on pinyon. George S. Meagher, junior forester, began research on juniper early in 1938. However, work was interrupted at the start of World War II, and afterwards the project was discontinued.

Pines and junipers are among the most successful plants in the North Temperature Zone. Both groups of conifers are well adapted to barren sites and as pioneer plants invade dry rocky slopes. In numbers of species, size, area, geographical distribution, habitats, and ecological niches they rank high. These two genera have spread through North America from near the northern limit of trees in Canada across continental United States from coast to coast and southward mainly in mountains to Mexico, tropical Central America, and the West Indies.

The junipers, genus *Juniperus,* have 14 species in the United States, about 15 more in Mexico, Guatemala, and the West Indies, and a world total of about 60. They are native in all 49 States of continental United States and are scattered across the prairie-plains grassland interior, as shown on Map 1, natural distribution in the New World.

The pines, genus *Pinus,* have 36 species in the United States, about 60 in the New World, and a world total of almost 100. Some grow wild in 48 States, all except Kansas and Hawaii, as charted on Map 2, natural distribution in the New World.

THE PINYON-JUNIPER WOODLAND

In the semiarid regions of southwestern United States northwest to the Great Basin and southward into the mountains of Mexico, the pines and junipers have entered and succeeded to form the pinyon-juniper woodland, a widespread vegetation zone of dwarf trees between the forests of the Rocky Mountains and the treeless lowland grasslands and deserts. This natural woodland type extends from southwestern Texas across New Mexico and Arizona to California and north into Nevada, Utah, and Colorado. Junipers continue northward through the five northwestern States, where they are conspicuous in the vegetation between the forested mountains and grassland plains. The area of this woodland from Texas to California has been estimated at more than 60,000,000 acres. The term juniper-pinyon woodland perhaps would be more appropriate than pinyon-juniper, because of the abundance of junipers and their broader geographic distribution. The aspect is similar, though the species composition changes somewhat from one State to another.

In the Southwest a remarkable group of pines has evolved. Pines adapted to this semiarid region by producing a distinct group, the pinyons or nut pines, *Pinus* subsect. Cembroides, with 8 species. Total natural distribution, within the United States and Mexico, is indicated in Map 3. Pinyons have limited leaf surfaces in short needles, the number in a cluster reduced from 5 in the white or soft pines commonly to 2 or 1. The cones produce relatively few, large wingless, edible seeds well adapted to dispersal and burial by rodents and other mammals.

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The common pinyon in the Southwest, sometimes distinguished as two-leaf pinyon, is *Pinus edulis* Engelm., Map 4. Singleleaf pinyon, *Pinus monophylla* Torr. & Frem., in the Great Basin extends south into northwestern Arizona. Mexican pinyon, *Pinus cembroides* Zucc., with needles mostly in 3's, ranges along the Mexican border from central and southwestern Texas to southeastern Arizona. Parry pinyon, *Pinus quadrifolia* Parl., the fourth species in the United States, with needles mostly in 4's, is rare in mountains of southern California but more common southward in northern Baja California, Mexico.

Descriptions of the 3 southwestern species of pinyons and of the 4 junipers and small maps of vegetation types may be found in "Southwestern Trees" (Little 1952). Species distribution maps are in the "Atlas" (Little 1971).

PINYON NUT HARVESTS

The most import product of the pinyon tree (not "pinyon pine") was its large edible nut (technically a seed). The Spanish name piñón (plural piñónes), referring to the large seed of *pino*, pine, has been anglicized to pinyon. A review of this wild nut crop may be appropriate here.

The large edible pinyon nuts have been a staple food of Southwestern Indians ever since arrival many thousand years ago. They were mentioned in reports of all the early Spanish explorers, back to Cabeza de Vaca, Fray Marcos, and Coronado, more than four hundred years ago.

Commercial harvest of pinyon nuts began early in the Twentieth Century. These nuts are similar to the large edible seeds or pignolias from Italian stone pine (*Pinus pinea)* imported from the Mediterranean region. A visitor from the East noticed the resemblance and began shipments to New York City. Pinyon nuts under the name Indian nuts were sold in pushcarts along city streets, especially to persons from southern Europe. The market expanded there, and smaller quantities were sent to other cities such as Chicago and Los Angeles.

The species involved in commercial shipments from New Mexico and northern Arizona was *Pinus edulis*. Its oily nut was preferred in flavor over the larger and thinner shelled, mealy nut of singleleaf pinyon, *Pinus monophylla,* of Nevada and western Utah. Number of fresh, unshelled nuts of the former is about 1,400 to 2,000 to a pound. Within a few months after harvest, there is a shrinkage of as much as 20 percent from loss of moisture.

Annual harvest in the Southwest in the 1930's was about 1,000,000 to 2,000,000 pounds. The largest recorded was 8,000,000 pounds in 1936. Raw unshelled nuts kept well in storage in the dry Southwest, sometimes a year or more until the surplus from large or bumper crops could be sold. They were packed in burlap bags of 100 pounds, or 40,000 pounds to a railroad carload. Thus 1,000,000 pounds occupied 25 carloads.

Pinyon was the largest entirely wild nut crop in the United States. However, its harvest was only a small fraction of that of cultivated nuts, such as pecan, walnut, almond, and filbert. Annual harvest of peanuts, an agricultural crop with similar edible seed, then was about 1,000,000,000 pounds, or nearly 1,000 times as great. (By 1976, current peanut production in the United States has increased to 3,800,000,000 pounds! And the Government buys the surplus!)

Pinyon nut crops, like good seed crops of other pines and various wild trees, are irregular. Large cone crops, the bumper crops, vary in time and place. According to popular superstition, there is a good pinyon nut crop every 7 years. Actually, the time between heavy crops in a locality may be as short as 5 years, rarely only 2 years, or somewhat longer near the range limits.

The commercial region for *Pinus edulis* centers in northern New Mexico, northern Arizona, and southwestern Colorado. Areas with the best and most frequent crops are northwestern New Mexico and northeastern Arizona. Commercial crops are produced occasionally in southern New Mexico.

Most pinyon nuts probably were harvested simply by hand under the trees after cones opened early in October. Where the nuts are abundant, a person can pick as many as 2 pounds an hour or 20 pounds a day. Another method is to rob nests of woodrats, or "packrats". Or the nuts and litter are swept with broom and separated by sieves of hardware cloth. Early in the season, before the nuts fall, a canvas can be put under a tree and the nuts and cones shaken or knocked out. Unopened cones are not picked in the Southwest.

In the 1930's the price paid to pickers was about 10 cents a pound. Local retail price of unshelled raw nuts was about 25 cents a pound. Most nuts were harvested on Government managed lands, mainly National Forests and Indian reservations. Pickers paid no fees.

The pinyon nut crop was gathered mainly by Indians, especially Navajos, and Spanish-Americans. Groups of Navajos would camp in the woodlands each autumn. They sold or bartered

their pinyons at the trading posts on the reservation. Most of the harvest was handled through two large wholesalers in Albuquerque. One bought all the nuts and stored surpluses from one year to the next. Thus it was able to maintain the price and perhaps make a low profit, partly through trading with Indians.

Pinyon nuts marketed locally in the Southwest were mostly unshelled and raw. Those shipped in carload lots to New York City and other cities were unshelled but roasted, polished, and cleaned. A relatively small amount was shelled in Albuquerque and sold roasted or sometimes in candy or confections. One local company developed a special shelling machine.

Thus, the pinyon nut harvest was a source of part-time employment and income for the pickers. This forest product brought some money into the Southwest every year. Also, local residents gathered nuts for home consumption and recreation.

The pinyon nut harvest and market declined rapidly during and after World War II. There was a shortage of labor for harvesting, and the price paid to pickers was forced upward. Also, there was competition with cheaper nuts.

Conversion of natural pinyon-juniper woodlands to grasslands in the Southwest has included destruction of mature pinyon trees on at least a few hundred thousand acres. Certainly the production of pinyon nuts has decreased, because large areas now are treeless.

At present the pinyon nut harvest probably is somewhat lower than before World War II, though figures are not available. Some shipments are made annually from Gallup, Albuquerque, and Flagstaff. One company in Albuquerque handles the local harvest and has a warehouse and shelling machinery.

Current prices (March 1977) in Albuquerque are approximately as follows: Pickers are paid $1.00 to $1.25 a pound. Retail price of raw unshelled nuts is about $1.75 a pound, or roasted unshelled nuts, $2.50 a pound. Also, roasted unshelled nuts are sold in packages, 3 ounces at $.79 and 4 ounces at $.98. Shelled roasted pinyon nuts cost about $5.00 a pound (from 2 pounds of unshelled nuts). These relative increases probably are comparable with those of other nuts through the years based upon higher costs of living and upon inflation.

EARLY RESEARCH ON PINYONS

My early research on pinyons in the Southwest, preliminary and basic, was mainly on the common pinyon, *Pinus edulis* Engelm., and was reported in several publications. These are cited in two detailed bibliographies on pinyon-juniper woodlands by Aldon and Springfield (1973) and by West, Cain, and Gifford (1973).

The classification or taxonomy of the pinyons was reviewed. It was obvious that there are four native species of pinyon, as in Forest Service Check Lists and named above, not a single species with four varieties differing merely in needle number. Basic differences of commercial as well as taxonomic importance were noted in the seeds, for example, size, thickness of seed coat, chemical composition, and taste (Little 1950). Afterwards, three minor botanical varieties were named. Detailed analyses of the chemical composition of pinyon nuts of different species were made by a cooperative study (Botkin and Shires 1948).

Fort Valley Experimental Forest, "the oldest forest experiment station", served as the headquarters for field work during the four-year period 1937-1941. It is located about 9 miles northwest of Flagstaff, Arizona, within the Coconino National Forest.

An experimental plot designated the Walnut Canyon Pinyon Plot was established in a good natural pinyon-juniper woodland also within the Coconino National Forest about 12 miles east of Flagstaff near Walnut Canyon and Walnut Canyon National Monument. In 1938 a 5-acre plot was fenced in Sec. 30, T. 21 N., R. 9 E. The site at about 6,500 feet altitude was within a few miles of the border of the ponderosa pine forest westward. A climatic station was maintained there and was visited weekly during the field season (Plate 1, lower left and lower right). Stages of growth of the trees, cones, and seeds were recorded (Little 1938a).

A detailed microscopic study of the developing cone, seed, and pollen was made. The stages were normal and like that of other species of pine studied previously. The cone requires two field seasons for maturation including one year between pollination and fertilization, as in nearly all pines. Also, as in other species, the earliest stages of the cones are formed in the terminal bud the preceding season and are distinguishable by August (Little 1938b). Thus, three growing seasons are involved in development of cone and seed.

The practical value of this fact, known to specialists, is that a bumper cone crop begins in the third year before maturity and requires three favorable years. Attempts to correlate cone crops with environmental conditions such as precipitation and temperature, should be dated accordingly.

A summary of the life history of pinyon

trees, including habitat conditions, was published later (Little 1965). Pinyon seedlings appear usually under the protective cover of low shrubs or in litter under the edge of the crown of parent trees, not in openings or grasslands. Shade and moisture are essential to survival of seedlings, according to an experiment with seed spots at the Walnut Canyon plot by George S: Meagher (1943).

Growth of pinyon trees is extremely slow, about 2 to 6 inches in height annually. Cones are not produced in quantities until trees reach mature size at an age of about 75 to 100 years. Mature trees are about 10 to 30 feet in height and 6 to 18 inches in trunk diameter and 75 to 200 years old up to a maximum of about 400. (The two oldest individuals measured elsewhere in tree-ring investigations were 973 and 853 years.)

At least a few young cones are formed by some trees in a locality each year, though in most years a particular locality has no commercial pinyon nut crop. When only a few cones begin development, mortality from insects and other causes is proportionately high and the cone crop at maturity is a failure. Obviously, a commercial pinyon nut crop is not produced unless the total number of cones beginning development greatly exceeds these losses and also the nuts harvested and stored by rodents before pickers arrive.

A special study of insects on pinyon was made (Little 1943). Insects destroy a very high percentage of cones of a light cone crop and a smaller proportion of a heavy cone crop. The first year, larvae of gall midges kill many cones. The second year, numerous cones and seeds are destroyed by caterpillars of pine cone moths, larvae of small weevils, and pinyon cone beetles.

One problem was how to manage pinyon-juniper woodlands to increase production of the edible seed, pinyon's most valuable product. The solution was simple, merely to pick more nuts. Somewhere in the vast area of pinyon-juniper wood in the Southwest, there is a good pinyon nut crop every year. The procedure was to locate the areas with trees bearing many cones and to pass this information on to pickers. For several years annual estimates or forecasts of the crop with locations were issued in summer (Little 1939, 1940). These were compiled mainly from observations by forest rangers on the National Forests. Similar reports could be resumed, if helpful.

Research was planned to attempt to increase future nut production on natural stands through management (Little 1941). It was suggested that in selection cutting, such as for mine timbers, the best nut producers be left (Little 1940). These mostly are large spreading trees with a broad crown and abundant old cones on the ground beneath.

Preliminary tests of treating trees to increase nut production were begun. These included watering, cultivation, addition of chemical fertilizers, and pruning. However, the work was not continued.

Slight variations in pinyon nuts from tree to tree were observed. Examples were number and size of nuts, also color shades and markings of seed coat. These individual differences could be the basis of some future improvement through selection.

Preliminary tests made to develop methods of controlled pollination and hybridization. Afterwards, the Institute of Forest Genetics of the Forest Service, at Placerville, California, has made interspecific hybrids of pinyons and is growing plants of the progeny.

CONVERSION FROM MULTIPLE USE TO ONE USE, GRAZING

The pinyon-juniper woodland has many uses, even though the unfavorable climate limits plant growth and total annual production per unit area. Obvious products of the wood include fuel, mine timbers, railroad crossties, lumber, novelties, fence posts, and pulpwood. In addition, pinyons provide pinyon nuts, Christmas trees, and ornamentals for transplanting. Other values are forage for livestock, food and habitat for wildlife, and recreation. Water yield from this zone of low precipitation apparently has been very low or negligible.

There were early reports that juniper was invading some areas of grassland in the Southwest. One day our supervisor, G. A. "Gus" Pearson took George S. Meagher to a place near Ashfork to observe the process. I was not invited because pinyons were not involved. Junipers in the Southwest may invade grasslands, just as eastern redcedar (*Juniperus virginiana*) spreads in pastures in the East. This increase apparently is related to grazing, including seed dispersal and trampling, and reduction of plant cover. (Possibly on some areas the junipers, properly managed, might be worth more than the forage.)

During my field work over the Southwest, I saw no evidence that pinyons invaded grasslands. Seedlings were found in the shade of a low shrub, such as rabbitbrush (*Chrysothamnus*) or the edge of the crown of a parent tree, never in the open grassland. Apparently livestock did not aid seed dispersal.

Sometime after World War II, widescale conversion of pinyon-juniper woodlands to grasslands was undertaken in the Southwest and with related species in the Intermountain or Great Basin Region. Treatment on a smaller scale continues at present. The process generally was called control of pinyon-juniper woodland that had invaded grassland.

Over large areas of the Southwest, conversion was accomplished by various methods, such as cabling, bulldozing, hand chopping, sawing, and grubbing, and burning, and even a giant machine called a tree crusher. In Arizona alone, more than a million acres of pinyon-juniper was treated in Arizona in the period 1950-1961, according to range specialists Arnold, Jameson, and Reid (1964, p. 24).

Most of the conversion was outside the National Forests, such as at lower altitudes. There, junipers apparently had invaded grasslands, mostly on the public domain. However, for several years, the acreage converted within the National Forests of New Mexico and Arizona was about 25,000 acres annually. Thus, at least 250,000 acres were treated.

Some information is contained in a 4-page leaflet entitled "Landscape management in pinyon-juniper control" issued by the Southwestern Region (U. S. Dep. Agric., Forest Service, no date). Color photographs included an aerial view of a "control project" of a natural stand, removal of large mature pinyons by a tree crusher, and increased forage production on a good treated site with ponderosa pine trees in the background.

In May 1968, after 30 years, I returned to my Walnut Canyon Pinyon Plot. The fence from untreated juniper posts was still in good condition. Many thousand acres of natural pinyon-juniper woodland for miles around had been converted to grassland and had become a desolate landscape. The area resembled the result of a severe fire, and part had been burned over. From the good pinyon woodland, only the 5 acres within the fenced plot remained, as shown in the six photographs of Plate 1.

This conversion represented a change from multiple use to one use, grazing. The location was near a city, where important values other than forage were lost. Conversion destroyed pinyons, Christmas trees, fuelwood, and fence posts. Also gone were wildlife including deer and other game animals, recreational areas, and scenic values. Here along a national highway and a branch to a National Monument, esthetic aspects should merit consideration. Numerous visitors daily could compare the orchardlike natural woodland with the destroyed woodland, now grassland. A century may lapse before pinyon recovers. However, juniper may come back rapidly.

Large-scale treatment was not preceded by adequate research or experimental plots. There was no previous study of costs and benefits nor of the duration and maintenance after conversion. At that time environmental impact statements were not required.

CONTROL AND CONVERSION

Two types of areas were treated in the Southwest under the term "control". First, the areas of grasslands, mostly at lower altitudes outside the National Forests, where juniper (but not pinyon) apparently had invaded. Treatment there could be called control or eradication.

Second, the areas of natural pinyon-juniper woodlands, such as the Walnut Canyon Pinyon Plot. There is no evidence that this type with mature trees 100-200 years old was formerly a grassland invaded by trees, nor that the trees had increased in density in recent years. Treatment there was conversion, not control.

Under some conditions one type of natural vegetation can be destroyed and replaced, just as a forest is cleared and followed by cultivated fields. However, without invasion, there is no control. The proper term for the artificial change from one vegetation type to another is conversion.

Pinyon (*Pinus edulis*) is a delicate species of extremely slow growth and long life. I have seen no evidence that pinyon invades grassland with juniper. Pinyon seedlings germinate in the shade of a tree or shrub, not in the open grassland. Height growth is only about 1 inch annually for the first 10 years or more. Mature pinyon trees 100 to 200 years old antedate heavy grazing by domestic livestock except possibly near very old Spanish-American settlements, such as limited areas of northern New Mexico. Pinyon plants can be seen growing in and overtopping low shrubs, such as rabbitbrush (*Chrysothamnus*) and sagebrush (*Artemisia tridentata*). Thus, over a long period of time, perhaps a century, pinyon might very slowly invade sagebrush or other shrub types. This change in vegetation probably is rare and mostly limited to the sagebrush type of northern New Mexico.

The term "conversion" should replace "control" in all discussion and planning involving treatment of natural pinyon-juniper woodlands, such as within the National Forests. There is a big difference in the two terms involving vegetation and policies of land management.

Conversion emphasizes that treatment is optional, and that lands may be left alone indefinitely with their natural plant cover. Also, costs and benefits and the effects of manipulation upon the environment should be considered. Further, a converted type may not be stable and may require repeated treatments for maintenance to prevent reversion. Conversion stresses the need for research before action.

SUGGESTIONS FOR FUTURE RESEARCH

This meeting devoted to the pinyon-juniper woodland demonstrates the renewed interest in this widespread vegetation type. Research is in progress at several localities. In conclusion, some suggestions for future research to make this type more productive may be offered here.

A general meeting on pinyon-juniper woodlands in the Southwest, similar to those on other vegetation types such as shrubs and desert plants, should be productive. The object would be to bring together the persons working in this type, both research and management, and should be of mutual benefit. This meeting would be mainly for Federal, State, and University workers but would be open to others, including conservationists, landowners and managers, and the scientific public. The program would include papers by researchers and administrators, field trips, discussions, and planning.

Review of past conversion from woodland to grassland would be desirable. Representative areas converted at different dates and by different methods could be compared. Economic analyses of costs and benefits would be useful. Any changes in composition of vegetation after conversion and the rates could be observed.

More basic research should be helpful in future management. These aspects perhaps merit the most attention: (1) timber management research, including silviculture, timber stand improvement, genetics (production of pinyon nuts, fence posts, etc.), and revegetation with woody plants, including exotics; (2) forest products, including development of new products and uses; and (3) forest economics and marketing, including studies of costs and benefits of different products and treatments.

Genetics offers possibilities for increasing productivity in the distant future. When developed, better pinyon nut bearing trees could gradually replace the wild stands. Junipers might be improved for growing fence posts. Pines better suited for lumber and pulp might be selected and bred. Careful land-use planning should precede future conversion. Multiple use, not just grazing, should be considered. Certain areas could be managed with emphasis on particular values, such as pinyon nuts, fence posts, Christmas trees, game, recreation, etc. On some good sites adjacent to privately owned ranches, conversion to grassland may be the best management.

On other areas, funds equal to cost of conversion to grassland might be better used for other purposes, such as timber stand improvement, revegetation with woody plants, and testing of exotics. Some marginal lands already converted might be restored or revegetated.

In the future, adequate review by specialists in different fields should precede projects involving destruction of natural pinyon-juniper woodland and conversion to grassland.

SUMMARY

From 1937 to 1941 I was assigned to the research project on the pinyon-juniper woodland in the Southwest to work on pinyon, *Pinus edulis*. Area of this woodland from Texas to California has been estimated at more than 60,000,000 acres. The most important product of the pinyon tree was its large edible nut.

The classification or taxonomy of the pinyons was reviewed. An experimental 5-acre fenced plot designated the Walnut Canyon Pinyon Plot was established within the Coconino National Forest about 12 miles east of Flagstaff. There, stages of growth of the trees, cones, and seeds were recorded.

At that time the solution to the problem of increasing production of pinyon nuts was merely to pick more. Annual estimates of the crop with locations were issued in summer. Research was planned to attempt to increase future nut production on natural stands through management.

Sometime after World War II, in the Southwest there was widescale conversion of pinyon-juniper woodlands to grassland from multiple use to one use, grazing. Many thousand acres around my plot were converted to grassland. Two types of treatment were applied under the single term "control". The first, refers to areas of grassland where juniper (but not pinyon) apparently had invaded. Second, the areas of natural pinyon-juniper woodlands, where the treatment was conversion, not control.

Some suggestions for future research to make the pinyon-juniper woodland more productive include a general meeting on pinyon-juniper woodlands in the Southwest and review of past conversion. Also more basic research in (1) tim-

ber management including silviculture, genetics, and revegetation; (2) forest products; and (3) forest economics and marketing. In the future, adequate review should precede conversion.

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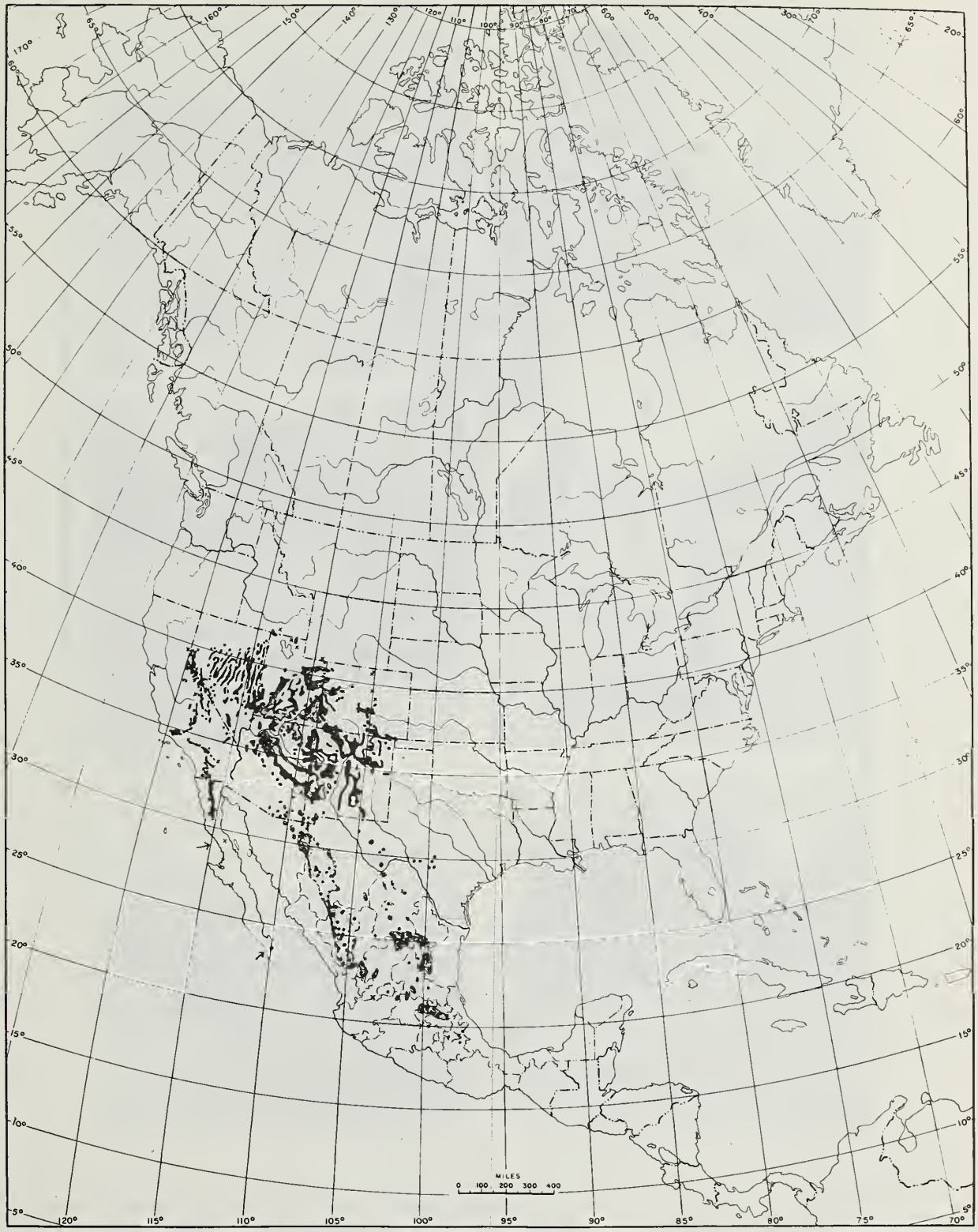
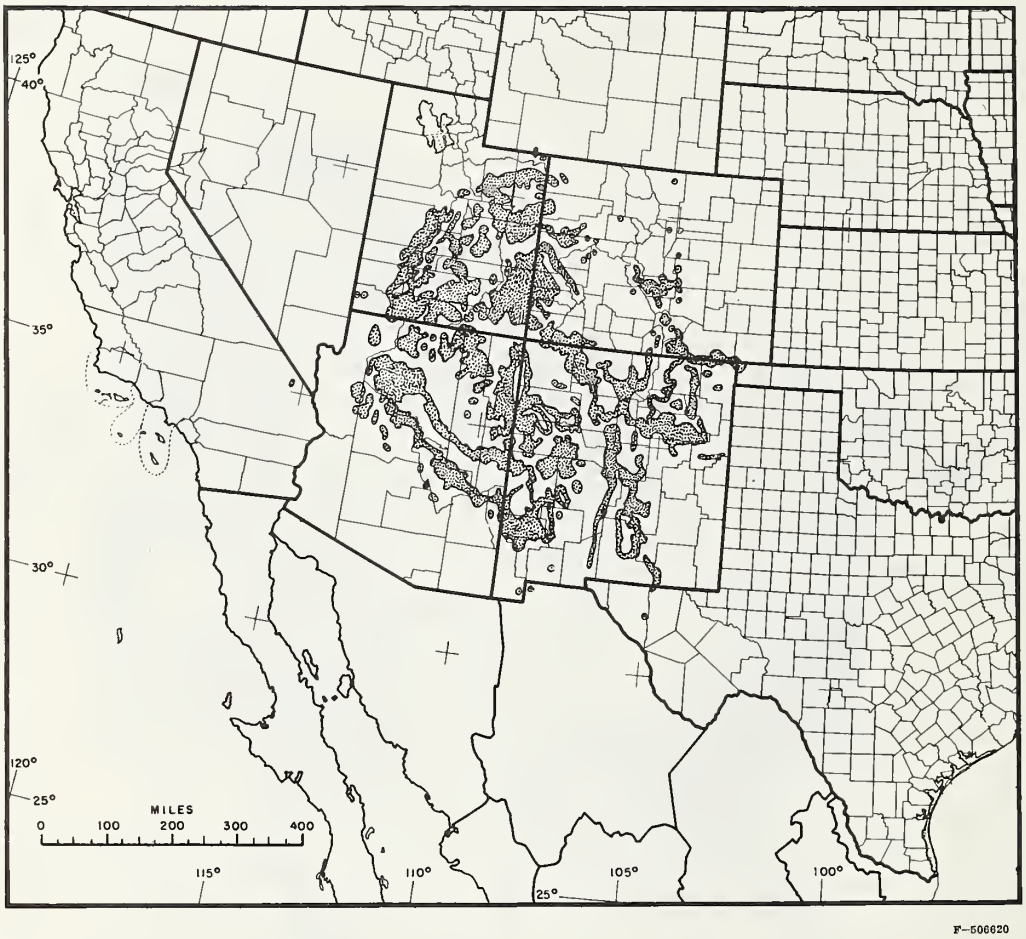
Map 1. Junipers (genus *Juniperus*), natural distribution in the New World.

Map 2. Pines (genus *Pinus*), natural distribution in the New World.



Map 3. Pinyons (*Pinus* subsection *Cembroides*), natural distribution in United States and Mexico.



Map 4. Pinyon, *Pinus edulis* Engelm., natural distribution.

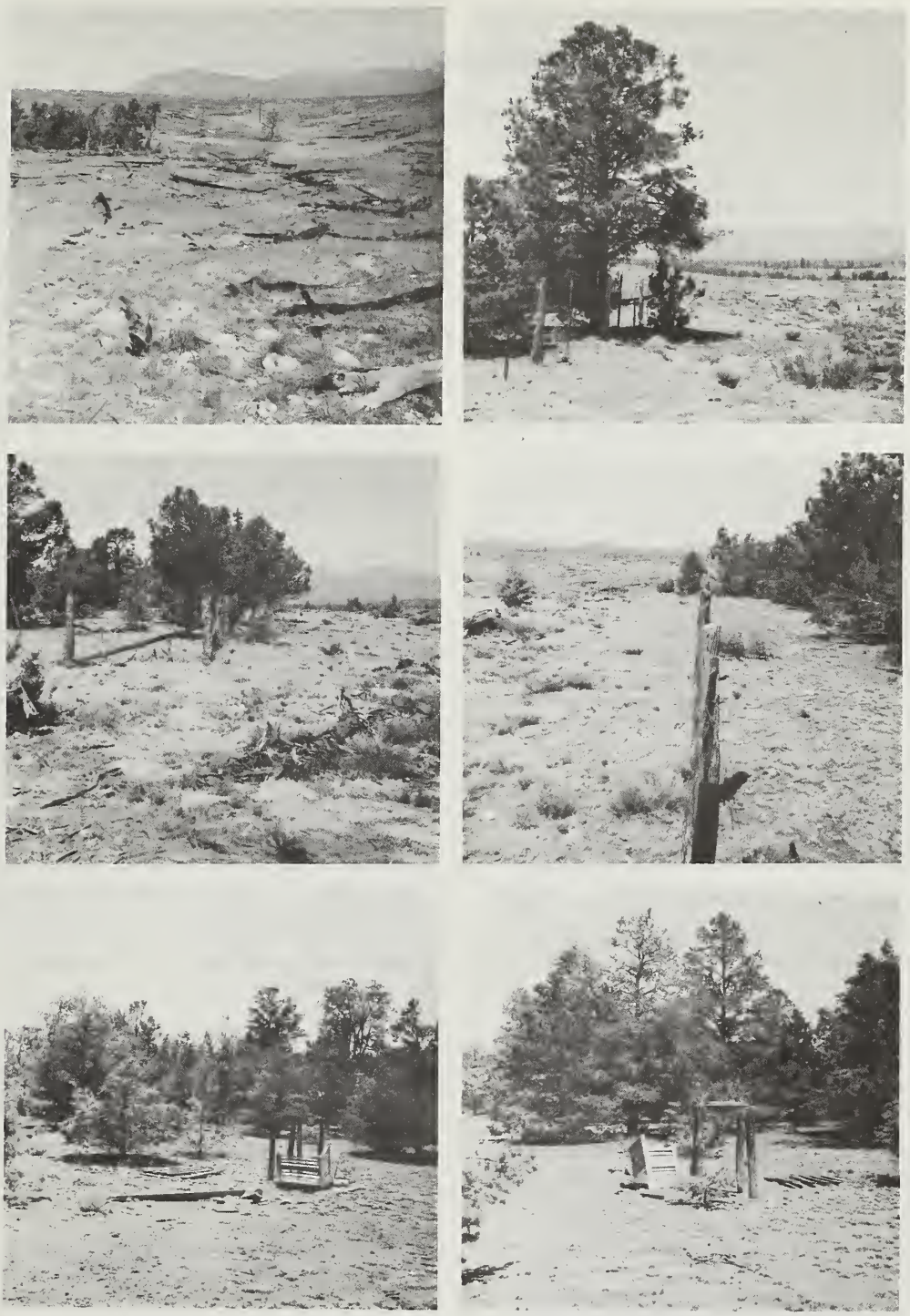


Plate 1. The Walnut Canyon Pinyon Plot 12 miles east of Flagstaff, Ariz., in May 1968, 30 years after establishment, six photographs. Upper left, upper right, and center left, three views of grassland after conversion, with 5-acre fenced plot of natural pinyon-juniper woodland at left, looking northwest toward San Francisco Peaks in background. Center right, looking northeast along fence, with woodland at right. Lower left and lower right, two views of the climatic station in an opening within the fenced plot, showing natural pinyon-juniper woodland and abandoned instrument shelter.

Insects and Diseases of Pinyon-Juniper

Tony Smith [1]

As the population of the southwest increases, more and more people are coming in contact with Pinyon-Juniper Woodland. Developments, summer homes, and expanding cities are encroaching into the P-J type. As a consequence, more attention is being given to the insects and diseases that attack pinyon and juniper. Some of these insects are important forest pests, some are important in the forest and in the ornamental situation, and some are important only on ornamental trees. Little will be said about diseases except to mention the mistletoes. True mistletoe infects juniper while dwarf mistletoe infects pinyon and they are the most important diseases of P-J. Pruning the infected branches is the only control for mistletoe on ornamentals.

Few insects attack juniper and those that do are not too common and rarely cause extensive damage or mortality. The most common insect that attacks juniper is a cerambycid twig girdler. It causes some twig mortality for a year or two and is a natural pruner of juniper but causes no important permanent damage to the tree.

Many different insects attack pinyon and the most common and important will be discussed here. Pinyon insects will be grouped by mode of feeding and type of damage caused as follows:

INSECTS THAT PRODUCE A CHARACTERISTIC PITCH FLOW AT THE POINT OF ATTACK

Pitch Nodule Moth. Larvae bore into twigs in early spring and produce a hollow ball of pitch about the size of a dime. Eventually the twig is killed and after several years of attack the trees are badly disfigured.

Pine Tip Moth. Orange colored larvae bore into tips and shoots and consume the pith. In June or July the tunneling kills the tip or shoot. Trees from 6 inches to 6 feet are most often attacked and this is an important pest of regeneration and nursery stock. A small 1/2 inch flow of drying pitch at the point where the larva bores into the tip indicates attack. The tips turn brown in summer and fall off the tree.

Ips Engraver Beetles. These beetles have 3 to 5 generations per year and usually cause mortality. Eggs are laid in typical galleries constructed under the bark and the larvae girdle the tree with their feeding in the cambium. Points of attack are marked by boring dust and by small flows of pitch called pitch tubes. Trees weakened by drought or by man's disturbances are attacked first and populations of beetles buildup and can successfully attack healthy trees. Slash is also a source of population buildups.

SUCKING INSECTS - INSECTS THAT REMOVE SAP FROM NEEDLES OR OTHER TREE PARTS

Pinyon Needle Scale. These insects attack and kill last year's foliage and can kill trees in 3 to 4 years time. They are difficult to control legally with insecticides. Unregistered systemics give 100 percent control. Region 3 FIDM personnel have developed an alternative to chemical control for ornamentals which consists of washing eggs off the tree with a garden hose and destroying them at the appropriate time. (See - Rky. Mt. For. and Range Exp. Sta. Res. Note RM-270.)

Pine Needle Scale. 1/16 inch white scale insects infesting pinyon needles, especially along dusty roads in areas of air pollution. They attack all pines and other conifers and can cause mortality in 3 to 5 years. Often weaken trees and make them susceptible to attack by other insects.

Conifer Aphids. Small, soft-bodied, long-legged insects which attack limbs, branches, and tree trunks. They feed by inserting their mouthparts through the bark. Many generations are produced each year and tree vigor declines rapidly. Mortality can occur in as little as 1 year.

DEFOLIATING INSECTS - INSECTS FEEDING ON NEEDLES

Sawflies. Insects related to bees and wasps. Larvae are gregarious, non-hairy, and feed on a branch until it is bare and then move on to another. They are sometimes pests in regeneration and in plantations, but are easily controlled with larval sprays.

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Tiger Moths. Hairy brown and yellow caterpillars up to 1 and 1/2 inches in length when full grown. They are active during the winter and early spring months when other insects are dormant. Young larvae spin silken tents enclosing a branch and then feed within the tent. Older larvae leave the tent and feed throughout the tree. Are sometimes pests in Christmas tree plantings. Tents can be pruned and burned with the larvae inside for control on ornamentals.

Needle Miners. Tiny moths which lay eggs on needles and the newly hatched larvae bore into the needles and eat the needles from the inside. Feeding eventually kills the needles which turn straw colored and drop off the tree. This insect has caused some areas of extensive mortality in New Mexico under natural conditions.

Pinyon-Juniper Wildlife Habitats

Ed Swenson[1]

Good Afternoon

First I want to say that I am not a researcher but a staff biologist. What I read and learn and investigate myself is catalogued into two compartments:

1. Gee whiz! isn't that interesting.

2. Hey, I can use this in my work.

I hope to stay in category 2 and try to inform you of what I have found useful about the P-J type and its associated wildlife - as well as describing some of the biological impacts of type-conversions.

As we know - most P-J or J-P woodlands are grazed - most of them on a yearlong basis. The history of grazing has been long - and has degraded the vegetative community so that most of the type exhibits low herbaceous and woody forage production.

But there's plenty of P-J and there are proven methods of converting the type to grassland with increases of 2 to 5 times for herbaceous production.

Now the P-J type also has a recognized value as wildlife habitat - most frequently mentioned are its values for cover - as well as a source of food - including juniper browse and berries-pinyon nuts - and forage from understory shrubs, forbs and grasses.

The literature, and I should add - the management plans and the EIS's - most often mention the game species which are associated with the P-J type - that is, the mule deer, elk, pronghorn, turkey - etc., for example - the value as winter range for elk and deer is often cited - and we read that 1/4 of the annual Arizona deer harvest is in this type.

However - when we dig a little deeper into the knowledge about the faunal characteristics of P-J we find that while there are a great many species which use the habitat seasonally - there are FEW OBLIGATE species - and these are the pinyon mouse, pinyon jay, plain titmouse and lead colored bushtit - species that do not turn on a lot of people.

So it's been the occasional users, the seasonal users - about which most of the information is available - and at the risk of losing you - these characteristically include - the large ungulates - mule deer, elk, pronghorn, bighorn sheep, the feral horse and burro - the lion, coyote, bobcat, weasel, gray fox, porcupine, the woodland cottontail, and black-tailed jackrabbit in winter, deer mice, pocket mice, least chipmunk, rock squirrel, several woodrats, the herps-horned lizard, red-spottedtoad, fence lizard, and western diamondback rattlesnake.

There has been a little more attention given to associated bird species - we know of the very reliable food source in the juniper berries - and the less reliable but highly attractive pinyon nuts - which bring in the band-tailed pigeon, turkey and the blue grouse at the higher elevations.

Breeding use and summer use is high - reflecting the value of this pygmy forest as an ecotone between the vast grasslands and the sharply elevated timber types.

Among the raptors we find that the ferruginous, swainsons, red-tailed and sparrow hawks and the great horned owl will nest in P-J.

Characteristic summer users include the broadtailed hummingbird, ash-throated flycatcher, say's phoebe, canyon wren, brown towhee, night hawk and poorwill.

During the winter months we find that a new assemblage of birds will move into the P-J including the mountain bluebird, mountain chickadee, white breasted nuthatch, house finch, scrub and stellars jays, robins, and loggerhead strike.

Not a lot is known about the food relations of many of these animals - however, the role of wildlife in seed dispersal is often mentioned - with the coyote, cottontail and several bird and rodent species being the culprits - I can attest to the heavy utilization of juniper berries by coyote - scats contain more berry than animal hair - and at long distances from juniper trees.

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[1]USDA, Soil Conservation Service, Albuquerque, New Mexico.

As expected - the food relations of big game species are best understood - generalities such as - "mule deer use Rocky Mountain juniper browse in the winter 'and' - elk use P-J primarily as cover, but eat the herbaceaous understory" - are commonly stated. And probably for browsing wildlife - the winter forage from woody plants IS THE major value of P-J habitats.

The role of late-winter and early spring green forage - the cool season grasses and early forbs - are often mentioned as a plus for deer and elk - and proposals for conversion projects make this point. But it remains unclear if this new source leads to additional use - while it is abundantly clear that winter use of seeded clearings is insignificant.

In reviewing management plans and EIS's for P-J conversion proposals - there is usually a statement made - which I will paraphrase - "the habitat diversity resulting from project X will result in a complex that is more suitable for big game animals and many birds" - and the new edge effect and improved vegetative diversity are normally mentioned.

The values of P-J thinning (or stand reduction) usually involving grass seedlings - also comes in for equally speculative and optimistic statements about anticipated benefits to wildlife - broadly to Big Game Species.

Let's look to some of the pertinent studies to evaluate these statements. - Studies of mule deer food habits demonstrate that the use of grasses is low and they are not utilized at the critical times of food shortages or when staple diet items are low in nutritional value. - Mule deer do not starve to death on P-J habitats in the spring or summer. A 1975 report by New Mexico Game and Fish at Fort Bayard gives us some insight.

They used tame deer - measuring bite count within a fenced enclosure - The pasture had a long history of livestock exclusion - good grass-blue & sideoats co-dominate with P-J canopy averaged 60 percent - going down to 10 percent in open parks. There were 189 plant species occurring - and 90 of them were utilized - but most interesting was that 90 percent of the annual diet was made up or arranged in descending order of utilization.

1. Mountain mahogany
2. Grayoak
3. Birdsbill day flower
4. Morning glory
5. Spiderwart
6. Deer vetch

No grass species!! The use of grass was highest in the spring with 1.6 percent of the diet - and less than 1 percent during fall and winter, while browse made up 92-99 percent in fall and winter - and 42 percent in summer.

So we must look again at values assigned to P-J type conversions for mule deer.

Studies of cause-effect in P-J conversions are few - and those available were aimed at Big Game. - The Utah Cooperative Wildlife Unit has studied three areas starting in 1959 - each area had been seeded to crested wheatgrass.

After determining deer days of use - by pellet group method, they concluded - one was higher, two the same, one lower. Using the same techniques they evaluated 16 conversions - rating them as 6 beneficial, 9 detrimental, and 1 no effect to deer.

In Arizona - McCulloch found no significant differences - P-J conversion areas were NOT improved as deer habitats. Those areas which did have exceptionally higher deer use were - small in size, excluded from livestock, had low tree kill, no slash removal, no seedings. These factors would probably rate the conversions as failures by most agencies!

Nevada reported on 4 conversions - deer use increased on 1, decreased on 1, and did not change on 2.

New Mexico Game and Fish reported in 1974 on Fort Bayard that elk and deer use was highest on undisturbed P-J, next on partially cleared, and lowest on total tree removal areas.

I will not go into the Fort Bayard studies done by Hudson Reynolds and others - you probably all are familiar with them - except to say that the big contribution made was to provide some factual basis for modifying type conversions in the attempt to limit habit degradation for deer and elk.

Studies of small mammal populations show initial increase in numbers for 3 years - then leveling off. Species dependent on trees (the pinyon and brush mouse) declined. Cleared areas support 40 percent higher rodent densities than natural P-J.

The response of the woodland cottontail - (*auduboni*) to type conversions showed their dependence upon a tree canopy or slash. Clean clearings lost this animal.

These studies indicate that conversion to grass has not been uniformly beneficial to mule deer - but also suggesting that elk probably benefit more.

One key ecological principal appears - wildlife diversity and numbers do not increase when vegetation diversity is reduced.

It's also evident that we frequently do not know, or cannot predict, just what the wildlife responses will be.

Here I would like to refer you to the 1971 Publication - "Game Range Improvement in New Mexico" put together by Sam Lamb and Rex Pieper under the auspices of the New Mexico Interagency Range Committee. Modifications in planning P-J conversions are suggested:

1. Leave at least 25 percent natural, particularly rocky points, ridges, and slopes over 15 percent on NE exposure.

2. Leave older, large crowned pinyons.

3. Leave 25 tall shrubs/acre.

4. Clear in strips no wider than 1/4 mile, with uncleared strips no less than 1/8 mile.

5. Add variety to seedlings.

6. Manage livestock.

I imagine that most agencies today are following these modifications.

About three years ago I decided to try and determine what the responses of wildlife had been to P-J conversions done here in New Mexico. My method has been to select ranches on which clearing had been done - find other pastures with similar soils and range sites that were uncleared, and compare. This is done by walking one to two mile belt transects and recording all animal signs in a 6 foot wide band. These transects are walked four times each year - in the four seasons. Comparisons are also made between heavy forage utilization and proper utilization operations.

Data has been collected for transects on four ranches as well as the Cibola and Santa Fe National Forests.

Without reciting a lot of raw data - let me very broadly give you some indications.

First - similarly to the research results, I found that type conversions do NOT greatly improve wildlife diversity or numbers.

Second - deer use is reduced, rodents increase, cottontail leave, black-tailed jackrabbits increase, ant colonies increase.

Third - the natural P-J has wider diversity and higher individuals of bird species - except sometimes during the winter months the seeded clearings will have a large number of a single flocking bird species.

Fourth - it is evident that those P-J stands which have not been overutilized - which have a broad composition of shrubs, forbs, and grasses - provide the best overall wildlife habitat - that is - more species, higher numbers, and yearlong users.

My recommendation is that we need to learn more; and until we can be more reliable in our information - we should not condone the sweeping generality that P-J type conversion is good for wildlife - as it appears that most often, it is not.

A Comparison Between Grazed and Ungrazed Juniper Woodland

Clay Baxter[1]

An ungrazed mesa was found 2 years ago southwest of Williams, Arizona. It has an elevation of about 5,980 feet and contains about 10 acres. It is totally inaccessible to livestock. Cottontail rabbits abound on the mesa. The surrounding vegetation is juniper woodland, containing an overstory of Utah juniper. Precipitation averages 10-12 inches.

During the past 10 years I thought blue grama to be an important forage species in the woodland type. Many people say that blue grama has been the salvation of the rancher here in the Southwest. I beleive this ... because, without blue grama most of the ranches in the woodland zone would be out of business since 99 percent of the desirable grass species that used to be there cannot be found - they were grazed out years ago! After seeing this mesa, I fully understand what we have done to the woodland zone.

What I am talking about does not necessarily pertain to all woodland areas in the southwest; for I have seen some that are not in too bad of a condition. But, it does pertain to a lot of range that I have seen. And, I fully expect that the comparison also pertains to most of the desert and semi-desert range found in the southwest.

This ungrazed mesa is an excellent area to compare with grazed rangeland in the woodland zone. In most cases, the mesa does not represent the "potential" of depleted ranges because their "potential" has been lost through the loss of top soil, the loss of soil fertility, the loss of a seed source, and soil compaction.

Today I would like to share with you the things that I have found and observed relative to this ungrazed mesa. I will compare:

1. Forage composition and its relative production

2. Management practices that have altered range resources

3. The condition of browse plants and

4. Soil conditions, as found on the mesa and on nearby grazed range.

I first visited the mesa in March of 1975. I was conducting a range re-analysis on an allotment and had been riding through typical juniper woodland in most of our range. Some of the woodland has blue grama with a little sideoats grama and galleta scattered throughout. Other areas have been completely denuded to the point where practically nothing other than Utah juniper exists. The rock cover you see on the top of the ground is the result of churning action of Vertisol soils. These pictures were taken in March, and in March very little green forage (other than some cool season growers still found in cactus or dense brush) can be found in the woodland zone - OR so I used to think before seeing this mesa. I suppose I thought the cool season grasses normally grew where I saw them. This is true, but not by choice! Two things went through my mind when I first saw this mesa: 1.) Look at all the green grass and 2.) Look at all the Beargrass (supposedly an Invader species).

It is obvious that there is a lot of green grass present in the vegetation seen here. Both mutton bluegrass and squirreltail make up over half of the composition on this mesa. This is obviously very impressive.

I really wondered about the Beargrass since it is not rated very high in our vegetation scorecards. (Decreaser for a Trace, 5 percent is Increaser, and balance as an Invader.) I asked a professor from N.A.U. (L. Fitzhugh) to visit the mesa and asked him about the Beargrass. He thought perhaps, that fire and grazing may have contributed to the loss below the mesa of Beargrass. There is not much found below the mesa. Beargrass, apparently, is not fire tolerant. (Light could be a cause too) Past fire history, as well as livestock and wildlife grazing probably has contributed to the loss of Beargrass. Livestock and wildlife were forced to graze Beargrass as green forage became more scarce. (Rodents will also utilize the leaves for nest material.) Consequently, Beargrass has just about disappeared from the grazed range below the mesa. As fire reduced the Beargrass cover, it was also important for keeping juniper from invading the open grasslands. As grazing reduced the grass cover, fire could not spread through the grass, killing the small invading

[1]USDA, Forest Service, Williams, Arizona

junipers. Also, the reduction in grass cover reduced the competition factor with juniper, allowing juniper to invade the grassland more rapidly. This competition factor probably is the major reason for the lack of juniper on the mesa since fire probably has not had much influence on this isolated piece of land.

I decided to put a permanent transect on the mesa to measure the vegetation. I put in one Parker Three Step transect. Ten species were tallied in the composition based on this transect. In addition, twenty other species were found on the mesa. Undoubtedly, there are other species present that have not been observed. Most of these species (Fourwing saltbush, black grama, vine mesquite, squirreltail, mutton bluegrass) cannot be found on the grazed range below. Range condition, based on the transect, is a low good, while it is a low poor to very poor elsewhere on this allotment.

I read eleven clusters on the allotment the same year. I compiled the data as seen here.

Table 1.--TRANSECT SPECIES COMPOSITION

Species	Relict Mesa	Continuous Grazing	Rest Rotation Grazing
Pofe	45%	0	25%
Sihy	15%	0	10%
Bocu	20%	3%	8%
Bogr	7%	77%	35%
Hija	3%	7%	10%
Muto	0	8%	2%
Forbs	10%	5%	10%
% Bare Ground	8%	65%	25%

There are three things that stand out to me here. ONE: Pofe and Sihy are cool season grasses and the composition on the mesa had 60 percent of these two species. Cool season species are very important in the fall and spring for both livestock and wildlife. Without them on the range, the animals are forced to graze browse plants for a longer period of time, often to the detriment of the browse plants.

TWO: Very little blue grama is found on the mesa while it is dominant on the grazed range. There is on 7 percent on the mesa while it is 77 percent below. It is very obvious that forage production will be higher on the mesa (900-1,000 pounds, air dried) than below (0-200 pounds).

THREE: Only 8 percent of the mesa contains bare ground while 65 percent below is bare ground. This is only on the transects. . .the mesa probably has less bare ground while the grazed range has more based on visual observations. This difference leads to obvious detrimental effects on the land - increased erosion. The effective ground cover on the mesa was found to be 97 percent on the mesa and is between zero and 16 percent below.

These differences are rather startling. The grazing history below the mesa was with cattle being grazed every winter without any management. There has been no fall or spring rest which is important to both the cool season grasses and browse plants. I decided, then, to see what has happened on another allotment with similar soils and similar precipitation but where management with proper stocking has been practiced for about 20 years. Fortunately some transects were established on this particular allotment prior to the establishment of a deferred rest rotation grazing system. The readings for one transect can be seen here:

Table 2.--COMPARISON BETWEEN TRANSECT READINGS FOR A THREE PASTURE DEFERRED REST ROTATION GRAZING SYSTEM

Hits on	1952	1957	1967
Decreaser	20	10	19
Increaser	39	60	111
Invaders	3	1	7
Rock	76	62	53
Litter	50	63	40
Bare Ground	112	104	70
% Cool Season Grasses	18%	16%	35%

The middle reading was about the time that management was initiated. The decreaser species had started out of the picture by 1957 while the increasers went up. Bare ground showed little change. Following 10 years of management with what appears to be proper stocking, the decreaser species improved as did the increasers. Bare ground showed a decrease of about 30 percent.

Some people will say that this change is due to lack of precipitation prior to 1957 and an increase after 1957. Moisture was slightly higher after 1957, BUT other transects on range being grazed under a continuous grazing system without rest or deferment showed little change or a downward trend during the same period of time.

Now, let's go back and compare species composition between the ungrazed mesa, the grazed range under management, and the range being grazed without management. We still have a 35 percent composition of cool season grasses on the range grazed properly. While we do have a 35 percent composition of blue grama, it is far better than the 77 percent found on the continuously grazed range. The rest rotation grazing system has allowed mutton bluegrass, squirreltail, and western wheatgrass to increase in the composition, as well as improving both plant vigor and plant density. The percentage of

bare ground is not so high either. Soils on the properly managed allotment are more stable and will improve faster than will sites on the allotment being grazed without proper management.

In addition to differences between grasses, one can see quite a difference in the condition of browse plants found on the mesa and on the range open to livestock grazing. Shrub live oak, mountain-mahogany, cliffrose, and fourwing saltbush can be found on the mesa. They have well developed, open crowns. They reflect plenty of leader growth. The plants on the open range are typically very heavily hedged with little leader growth. Some stands are very decadent. All reflect heavy utilization. When the more desirable browse species start to receive extreme use, the less desirable species such as algerita, hop tree, skunkbush, and shrub live oak start to reflect use.

Everyone says that livestock condition is a reflection of range condition. This is a picture of a cow that is not in poor shape. The range she came from looks almost like the corral she is standing in. It is pretty bad, obviously. The dark object seen in her mouth is a piece of black plastic pipe. She will eat what is available. Given some supplement, she can stay in good condition. However, I don't believe that we want our rangeland to look like this corral even though some do .....

One might question if there are soil differences that would explain the differences in vegetation found on the mesa and below. I asked our soil scientist to see what kind of soil was on the mesa and to compare it against what they found below (a soils analysis was made previously on the allotment around the mesa. They found the soils to be very similar in that they are moderately deep 20-40"), fine textured clay and clay loam soils forming on basalt parent material. They have large quantities of rock in their profile. The clay fraction is dominated by montmorillontic clay. The taxonomic classification is *typic argiustoll, clayey-skeletal, montmorillonitic, mesic,* with *vertic* and *lithic* integrades. This is where the similarity ends. Soil compaction is dominant on the grazed range but is not present on the mesa. There is little or no soil structure on sites below the mesa while soils on the mesa exhibit strong granular structure on the surface horizon, and moderate to strong subangular blocky structure in subsurface horizons. The compaction found below the mesa produces negative soil properties such as increased soil erosion, decreased water infiltration rates, unbalanced soil atmosphere, and reduced soil fertility causing an overall reduction in soil potential.

In summary, what we have seen here today cannot be fully appreciated without actually seeing the mesa in person. Pictures do not give it justice. While the relict mesa is the best rangeland I have ever seen in the juniper woodland - it does not reflect the true potential of the land found in the woodland around the mesa. This is because past history has reduced the site potential through soil and vegetation degradation. It will never return to the potential it once had. But, through proper livestock management and range development, I believe the range can be improved over what it is at the present. <u>The longer the woodland continues to be abused, the lower its potential will be and the longer it will take to reach that potential</u>.

Product Potential of Pinyon-Juniper Woodlands

Peter F. Ffolliott[1]

In general, the pinyon-juniper woodlands in the Southwest are normally considered of less commercial value than the saw log forests of higher elevations. However, ever since the earliest days of Spanish exploration and settlement, the woodland species have been a source of fuelwood, posts, poles, and even some food (Fogg 1966, Hamilton 1965, Randles 1949, Reveal 1944). More recently, these species have gained attention as a potential source of raw material for paper, particleboard, charcoal, extractives, and novelty items.

The purpose of this paper is to describe some of the physical properties of pinyon and juniper tree species, specifically, how these properties determine woodland product potential. Much of the material for this paper has been gleaned from a larger, more detailed report on the physical characteristics and utilization potential of the pinyon-juniper woodlands (Barger and Ffolliott 1972).

WOOD PRODUCT DETERMINANTS

Opportunities for utilizing the pinyon-juniper woodland species depend, in part, upon such physical properties of the woods as weight or density, mechanical strength, shrinkage characteristics, and visual features (i.e., texture and color). Some knowledge of these physical properties and their variability is a necessary requirement for evaluating utilization potential.

Mechanical strength characteristics are important for uses in which wood members are, or may be, placed under load: posts, poles, ties, and structural timbers, for example. For use in furniture, novelties, or smaller turned or shaped products, hardness, texture, color, fragrance, shrinkage, and finishing characteristics may be of primary importance. Physical characteristics such as density and fiber length affect the yield and quality of chemically derived products, including pulp and charcoal.

The characteristic form and size of trees also help to determine the uses for which the wood may be suitable. Relatively large, uniform stems (i.e., ponderosa pine and Douglas fir) are required for the production of standard lumber, large timbers, or commercial poles. Unfortunately, the pinyon-juniper woodland species do not generally produce stems suitable for such products. Many other products can be produced, however, from the smaller, more irregular stems due to the unique physical characteristics (i.e., fragrance and color) which are common to pinyon and juniper trees.

SPECIFIC GRAVITY

Specific gravity or density is the simplest and most useful single index to the suitability of wood for many uses. Specific gravity is closely related to the mechanical strength of wood and determines, to a large extent, the yield of products such as pulp and charcoal. In addition, it provides a means of estimating strength, shock resistance, and hardness. The variability in specific gravity also indicates, to some degree, the variability to be expected in associated physical properties.

To obtain a measure of specific gravity for pinyon and juniper trees in the Southwest, full-length increment cores have been collected from a random sample of approximately 50 trees of each major species (Barger and Ffolliott 1972). The sample represents a range of site and growth conditions that extend from the ponderosa pine woodland species intermixture above to the chaparral shrub zone below.

The woods of pinyon and juniper tree species contain appreciable quantities of extractive chemicals. Since most strength characteristics and product yields are considered a function of cell wall material, specific gravity based on extracted wood may be a better index of such properties. Therefore, to determine extractive content and extracted specific gravity, extractives were removed from the sample of increment cores. An ethyl alcohol-benzene solvent and hot water were used successively to remove most of the extractives.[2] Specific gravity of pinyon, Utah juniper, and alligator juniper was then determined for the cores before and after extraction (Table 1) by analytic procedures

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[2]Increment core extractions were performed by procedures developed by Glenn Voorhies, formerly with the School of Forestry, Northern Arizona University, Flagstaff, with extraction in the NAU Wood Technology Department.

developed by the USDA Forest Products Laboratory (USDA Forest Service 1956). Specific gravity is a direct measure of the density of wood, which is normally expressed in pound per cubic foot of unextracted wood.

Table 1.--Specific gravity of unextracted and extracted increment cores of woodland species.[1]

Species	Unextracted			Extracted		
	Range		Mean	Range		Mean
	Maxi.	Mini.		Maxi.	Mini.	
Pinyon	0.624	0.430	0.506	0.580	0.405	0.484
Utah juniper	.682	.439	.511	.605	.390	.466
Alligator juniper	.533	.372	.453	.486	.356	.426

[1]Based on ovendry weight and green volume.

Density is one of the properties of wood that affect the yield of pulp. Generally, the denser woods yield more pulp per unit volume of solid wood processed. Both pinyon and the junipers are relatively dense compared to other western softwoods, averaging 10 to 20 percent heavier than ponderosa pine, for example.

All of the pinyon-juniper woodland species are suitable raw material for charcoal. As all wood is about 50 percent carbon, charcoal yields will generally be proportional to the density of the wood. Denser species, such as pinyon and juniper, are often preferred since charcoal yield per unit of wood volume will be greater.

STRENGTH AND RELATED PROPERTIES

Strength properties, which indicate how well a wood member resists a variety of loads or forces, can be determined directly through tests of small wood samples or can be estimated indirectly from specific gravity. Strength characteristics determined from actual mechanical tests (Table 2) are available for pinyon and alligator juniper (Markwardt and Wilson 1935). These test values may also be used to calculate working stresses, load-carrying capacities, and similar values.

Table 2.--Strength properties of the air-dry wood of three woodland species (Markwardt and Wilson 1935).[1]

Property	Unit of Measure	Pinyon	Alligator juniper
Static bending strength:			
Stress at proportional limit	Lb/sq. in	5,600	5,400
Modulus of rupture	Lb/sq. in	7,800	6,700
Modulus of elasticity	M lb/sq. in	1,140	650
Total Work	In.-lb/cu in	6.1	---
Compressive strength:			
Maximum crushing strength parallel to grain	Lb/sq. in	6,400	4,120
Stress at proportional limit, perpendicular to grain	Lb/sq. in	1,520	1,700
Hardness:			
End	Lb.	920	1,290
Side	Lb.	860	1,160

[1]All values are adjusted to a uniform air-dry condition of 12 percent moisture content.

Index values describing major strength and physical properties may be useful in comparing the properties of one wood with another or in choosing a wood outstanding in some particular property. For example, index values for pinyon, alligator juniper, and, for comparative purposes, ponderosa pine (Table 3) are based on combined strength values representing each of six major properties (Markwardt 1930). Using these data, it may be possible to weigh the advantages of one woodland species against another or those of a woodland species against a tree species of assumed higher commercial value, and then select the species with the most desirable features.

Table 3.--Average comparative index[1] of properties of the clear wood of selected woodland species and two common commercial species (Markwardt 1930).

Property	Pinyon	Alligator juniper	Ponderosa pine
	Comparative index		
Bending strength	60	63	65
Compressive strength	75	76	69
Stiffness	108	60	112
Hardness	73	107	41
Shock resistance	65	79	58
Volumetric shrinkage	99	73	97

[1]The numbers are index values based upon a weighted combination of specific strength values related to each of the six essential physical properties. Strength tests of both green and air-dry material were used; the final index values represent a condition of approximately 20 percent moisture content.

Many strength and associated physical properties of wood are closely related to specific gravity. As a matter of fact, empirical equations expressing the relationships of specific gravity to other physical properties have been developed by the USDA Forest Products Laboratory (Markwardt 1930, USDA Forest Service 1956). Since these equations are based on a large volume of source data, predicted strength values may be more reliable than actual strength tests carried out on a small number of samples. Although specific gravity of unextracted wood is commonly used in the computations, values for extracted wood may yield more accurate results. Therefore, strength values based on specific gravity of both unextracted and extracted wood have been calculated and reported (Barger and Ffolliott 1972) for the major pinyon-juniper woodland species in the Southwest.

FACTORS AFFECTING STRENGTH

Strength values are based upon, or calculated for, clear wood specimens. Defects such as knots, decay, or irregular grain will affect many, but not necessarily all, of the strength properties of the wood. For example, knots have little effect upon compressive strength or stiffness.

Strength may also vary due to growth rate, growth conditions peculiar to the tree or locality, or any other factor that influences specific gravity. Strength may even vary between trees of the same species growing in the same locality, as demonstrated by the range of specific gravity often encountered in a small geographic area (Table 1). For many species, specific gravity also decreases with the height of the tree, resulting in stronger wood near the butt of the tree, and weaker wood near the top. Also, juvenile wood near the pith is often more rapidly grown and less dense than wood from other parts of the tree. Finally, both the pinyon species and the juniper species that are common to the Southwest hybridize occasionally, adding to the possibility of inherent variation due to genetic strain.

Moisture content has a pronounced effect upon most strength properties, as indicated by comparative strength values for green and air-dry wood. Most strength properties increase rapidly as wood dries below the fiber saturation point, although the various strength properties are not equally affected. Average variations in physical and mechanical properties due to random variation in a species, and due to changes in moisture content, have been estimated and reported (Barger and Ffolliott 1972, Markwardt and Wilson 1935) for many of the pinyon-juniper woodland species in the Southwest.

SHRINKAGE CHARACTERISTICS

Wood shrinks when it dries below the fiber saturation point of 25 to 30 percent moisture content. Normal wood shrinks a substantial amount transversely, general expressed as radial (across rings) and tangential (parallel to rings) shrinkage. Larger differences between radial and tangential shrinkage indicate a greater tendency to check and cup during drying. Percent shrinkage values from green to oven-dry condition for pinyon, alligator juniper, and, for comparative purposes, ponderosa pine (Table 4) are nearly twice the shrinkage that will occur between green and an average air-dry condition of 12 to 15 percent (Markwardt and Wilson 1935).

Table 4.--Shrinkage characteristics of the wood of selected woodland species and ponderosa pine (adapted from Markwardt and Wilson 1935).

Species	Shrinkage property		
	Radial	Tangential	Volumetric
	Percent		
Woodland:			
Pinyon	4.6	5.2	9.9
Alligator juniper	2.7	3.6	7.8
Ponderosa pine	3.9	6.3	9.6

CONCLUSIONS

The general physical properties of pinyon and juniper trees in the Southwest do seem to indicate opportunities for increased use of the woodlands in terms of wood product recovery. It is conceivable that, in addition to the traditionally derived products such as fuelwood, posts, and poles, the pinyon-juniper woodlands may provide a sizable wood fiber resource for new products including pulp, particleboard, charcoal, and extractives. Of course, whether or not these potentials are realized depends largely upon the availability of suitable market outlets, along with other economic considerations such as efficient tree harvesting and wood processing operations.

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What Is Known and Not Known About Pinyon-Juniper Utilization

Glenn Voorhies[1]

The absence of commercial utilization of the Pinyon-Juniper woodland resource is difficult to understand, particularly so for those individuals who are not familiar with the characteristics of the stand components.

The stem form and board foot volume per acre detracts from a profitable saw log operation. The possibility exists, however, of harvesting selected trees of good form with sufficient bole length to produce lumber or other products for a specialized market. If logs from 3 feet to 8 feet long and 8 inches and larger in diameter are available, varying product potential exists.

Manufacture to lumber or cants on site can proceed with a portable bolter sawmill or by a chain saw filed for ripping. In the latter case, the log can be held firmly in a frame and the chain saw, with a six foot bar, made to ride on a rolling carriage with the frame acting as a guide. Preferred by some operators, a small flat-bed truck with a power take-off boom will load and haul the logs to a permanent mill site. The sawn lumber, in thickness up to 8/4, can be successfully air dried to 10 percent moisture content provided the stock is not exposed to a very low relative humidity. Limited tests indicate 7/4 Juniper may be dried in 60 hours or less when temperature in excess of 220°F. is used. For furniture, panel stock and novelties, the moisture content of the wood must be reduced to 6 percent or less in order to prevent checking in use.

Deep chipped grain can be avoided only by using a sanding surfacer on knotty stock. The knots are rather soft and sand easily. A cutter head surfacer is satisfactory for clear, straight grained wood, even when finger jointed.

Examples of richly colored wall paneling, furniture, especially tables, selling on the retail market up to $600, lamp blanks and numerous novelties can be found at specialized wood working shops.

A parallel to this type of utilization can also be found in Southern Arizona where Mesquite lumber and veneer is produced and fabricated into a line of furniture as well as custom products.

Juniper can also be sliced to veneer thickness from moist hot flitches.

Another attribute of Juniper is the durability of the heartwood as exemplified to the various fungi-toxic extractives present in the wood. These extractives are the source of the aromatic odor, found to varying intensity, in the heartwood, of all Junipers.

The extractives from both the wood and needles of Juniper and Pinyon Pine have been studied by many investigators. From the extractives of Utah Juniper, 12 or more individual compounds have been identified. The compounds which make up the extractive content may be useful in medicine and are a basis for perfumery, are used in cleansing compounds, microscopy and various industrial uses.

The yield of extractives from operations in the "Cedar Breaks" area of Texas are reported to be from 2 percent to 4 percent based on the oven dry weight of the wood.

The most recent investigation of Pinyon-Juniper extractives known to the author is that by Dr. J. E. Simpson of the Small Business Administration in Washington, D. C. This work took place almost as a corollary of the Pine stump wood investigation. The yields, without a breakdown of the chemical compounds, were found by the Olustee Florida Naval Stores laboratory to be as follows:

Item	Utah	Allig	Rocky Mt	Pinyon
% Moisture Content	38	31	9	29
Distilled Oil				
Gallons/Ton	2.1	3.0	9.0	1.7
1 /Ton	15.1	21.	64.8	12.2
Acidic				
(Rosin-like)				
lb./Ton	67.2	87.3	113.5	43.5
Total	82.3	108.3	178.3	55.7
Percent	4.1	5.4	8.9	2.78

Leaf oils and extracts are not included.

Dr. Simpson remarked that "the yields were not sufficient to justify an operation for extractives alone." Additional products from the residuals need to be investigated.

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Field chipping of the entire tree has been suggested as a method of harvesting Juniper on a clear cut basis. Mechanized felling with shears, grapple skidding of the bunched stems to a portable field chipping unit would produce whole tree chips. The chips might then be transported to a central stock pile for subsequent debarking. Such chips might then be extracted, used for pulp or compacted into pellets or fuel logs by using something like the Hausmann briquette machine. In the latter case, the chips would have to be dry to 10 or 12 percent and further hammermilled.

Another alternative for chip use is pulp manufacture. Experimental sulfate pulp has been made from Juniper but of somewhat lower quality than that made from ponderosa pine. The lower strength may be, in part, attributed to a shorter fiber length as well as to the extractives. Debarking of either the chips or rough bolts could well be a deterrent to a bark free chip furnish.

The debarking of whole tree chips may soon become a reality as intensive studies are being made to separate the wood from the attached bark.

Wood and bark, especially wood residues, enjoys a continually rising demand for in plant process energy. Studies made by H. C. Mason show that when residual fuel oil sells at $15.00 per barrel, the value of moisture free hogged fuel has a value of about $30.00 per ton, assuming equal burning efficiency. A correction factor must be applied when burning wet hog fuel as a portion of the wood energy value is consumed in evaporating the water in the wood. The heat value for both Pinyon Pine and Juniper is approximately 9000 B.T.U.'s per pound of dry wood when burned at 100 percent efficiency.

Alternative harvesting systems for thick Juniper stands appear to be available. Whether to use a machine such as hypothesized by Koch and McKenzie, or the Nicholson or Morebank whole tree chipping system, would be dependent on cost and the end products envisioned.

If fuel is to be the prime product for nearby consumption, the wood burning steam boiler or the "fluid flame," fluid bed, or similar systems can handle wet hog fuel. On the other hand, the "Energex" system uses only dry, fairly fine comminuted wood as fuel. The latter system is in use at the Navajo Forest Products Industries Particle Board plant at Navajo, New Mexico. The March 1977 issue of Crows Lumber Digest reports on a veneer drying operation in the State of Washington using the Energex burner for heating a direct-fired veneer dryer. The use of wood residuals has resulted in a saving of $477,000 per year over the prior costs of burning propane.

Charcoal production from wood and wood residuals has long been an intriguing concept for disposition of low grade wood at a profit. Whether a charcoal kiln or some type of a rotary mechanism is used, the recovery of char remains at only 28 to 32 percent of the oven dry weight of the wood. Even when the wood comes free, as in residuals, the result may be a marginal profit.

During the 1974 fuel crisis, one Arkansas plant with installed charcoal making capacity did harvest scrub hardwood to produce fuel. The wood gases evolved during manufacture of char have a heat value per cubic foot of about one-half that of natural gas.

The Pinyon Pine potential for multiproduct harvesting has probably not been intensely researched. Currently, lumber and ties, along with the pinyon nut harvest are the prime products of considerable value.

This presentation has not developed any costs and benefit values, nor has it explored market or demand potentials; for the most part, these are unknown quantities. It is fortunate that the Pinyon-Juniper resource can be "stored on the stump" until some of the potential economic uses unfold.

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Management of Pinyon for Ornamentals, Christmas Trees, and Nut Production

James T. Fisher and Jose M. Montano[1]

Tree invasion and increases in tree density pose serious problems to optimum use of the pinyon-juniper type in many areas of the Southwest (Springfield, 1976). Tree removal is expensive, and under recent economical conditions, the more successful conversion attempts just about break even from the standpoint of benefit-cost (Clarey et al., 1974). The sale of conversion or thinning by-products such as firewood, Christmas trees, nursery stock, and pinyon nuts may determine, to some extent, whether a net loss or gain is recorded for the project.

In Colorado, for example, a rancher cleared 200 acres of pinyon-juniper, bulldozed branches from the trees into gullies to prevent further erosion, and broadcast native grass seed over the entire area(Alessi, 1968). Enough pinyon trees were sold to nurseries from Denver and Colorado Springs to pay for removing the brush. Buyers came to the ranch and balled the trees for ornamental purposes.

Pinyon-juniper stands on fairly level terrain and modestly deep soils offer the best possibilities for conversion to grassland (Springfield, 1976). The same stands usually produce trees with growth forms acceptable for Christmas trees and ornamentals.

Removal of pinyon Christmas trees and nursery stock can be combined with chaining or cabling, since these operations effectively kill only trees greater than 10 feet tall (Springfield, 1976). If smaller trees are not removed, release from dominance by the taller trees stimulates growth to the extent that the latter case may become worse than the former.

In addition to reducing tree density, selective thinning of pinyon trees can result in better nut crops. Applications of additional cultural practices to favor nut production might also be financially rewarding.

This paper will include suggestions on how to manage pinyon-juniper stands for Christmas trees, nursery stock, and nut production. The practices discussed here could apply to conversion, thinning, or sustained operations.

NUT PRODUCTION

Pinyon nuts have been harvested commercially for about 40 years (Little, 1938a). The pinyon nut crop averages 1 to 2 million pounds annually for New Mexico, Arizona, and Colorado, but one year exceeded 8 million pounds (Little, 1941). The better natural stands may yield 300 pounds of nuts per acre during a good year (Springfield, 1976). At the current retail value of $2.50 per pound, value on a per acre basis would be $750.

Because pinyon nuts constitute a regionally valuable crop, more emphasis should be given to practical techniques for stimulating production in natural stands. Before discussing these techniques, it might be helpful to mention the factors thought to strongly influence fruitfulness in pines.

According to Schmidtling (1974), most studies on fruitfulness in conifers point to the fact that positive responses to experimental treatments can be explained on the basis of increased N or amino acid availability at the critical time of ovulate primordia formation, although the importance of carbohydrates cannot be completely discounted.

Schmidtling produced a schematic (Figure 1) showing the interrelationships between the factors influencing flowering in conifers. On the right of the figure is shown the influence of thinning, cone crop, and fertilization on flowering as they affect nitrogen accumulation.

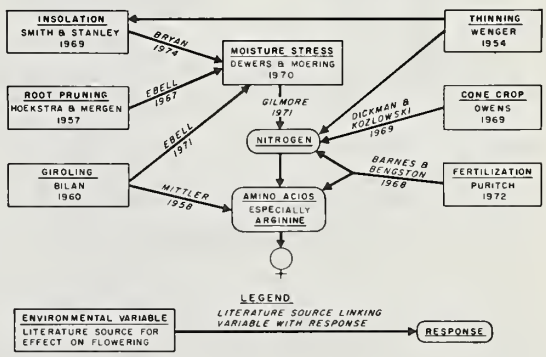

Fig. 1. Interrelationship between factors influencing flowering in conifers (R.C. Schmidtling, 1974)

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Thinning reduces competition for nutrients and theoretically should make more N available to the tree. One might argue that the effect may be due to increased moisture supply, but there are studies that would not support this explanation.

Most research on flowering in conifers has examined the role of mineral nutrients, especially the effects of fertilization. Puritch (1972) tabulated 25 references in which fertilizers were applied to conifers and in all but three, fertilizers stimulated female cone production. More specifically, the studies collectively showed the following trends:

1. N is a key component in fertilizer response. For example, in an NPK factorial experiment with slash pine, Morris and Beers (1969) found that N stimulated flowering. Also, it has been shown that good cone producers have a higher proportion of N in their foliage than poor cone producers.

2. N content per se may not be important but the accumulation of amino acids, especially arginine is. For example, Ebell and McMullan (1970) found that nitrate N and ammonium N increased foliar N content and shoot growth in Douglas-fir by similar amounts, but only nitrate N increased female flower production. Free arginine content was greater in nitrate-treated trees than in the others, and appeared to be quantitively associated with increased flower production.

A large cone crop with its drain on nutrients has been associated with periodicity of cone crops (Owens, 1969; Ebell, 1971). It has been shown that developing cones act as sinks for carbohydrate and N reserves at the expense of vegetative structures (Dickmann and Kozlowski, 1969; 1970; Rook and Sweet, 1971). Indeed, large cone crops in conifers have marked effect on radial increment (Eis et al., 1965).

On the left of Figure 1 are those factors that indirectly determine N content through influencing moisture stress. Many studies have shown that moisture stress during the summer results in a better-than-average flower crop the following spring. This suggests that moisture stress, at the time of ovulate primordia formation, promotes reproductive rather than vegetative growth. Circumstantial evidence linking stress with cone production is found in the work of Wareing (1958), who showed that plant water potential was more negative, (i.e., moisture stress was greater) toward the top and toward the extremities of the branches. In these same areas, female cone production in pines is heaviest. Further, water potential was more negative on the side receiving the most sun, which is the side where female flowers are most numerous.

Ebell (1970) suggested a link between water stress and nutrient status. He showed that fertilizing with nitrate or subjecting Douglas firs to water stress not only elicited similar flowering response, but also brought about similar increases in total N content and free amino acids, especially arginine. Schmidtling's (1974) schematic suggests that water stress and N fertilization may increase flowering through the same metabolic intemediary, arginine or some related N-containing substance.

Rainfall, in general, is positively correlated with flowering. This is because in times of the year other than when ovulate primordia are being initiated the need is for photosynthate production so that carbohydrate reserves are made available when needed. For example, low June and July rainfall would reduce photosynthesis, and thereby, reduce flowering.

In the schematic, one can see that root pruning and girdling can be used to artificially stimulate flowering through increasing moisture stress. Girdling can also directly affect organic nitrogen content.

With these factors in mind, one can review fruitfulness of pinyon and consider how it might be stimulated.

Pinyon trees start bearing nuts at about 25 years, but crops do not reach commercial size until 75 years (Little, 1941). Cones are borne laterally in the axil of a scale leaf near branch tips (Shaw, 1914), although a rare observation of terminal cones has been reported (Lanner, 1969).

Developing cones can be seen in the earliest stages as ovulate primordia in longitudinal sections of buds. They can be distinguished from spur shoots in buds by being located only at the tip of the buds, and by having larger and broader bases (Little, 1938b). Buds are formed in August and September, and the cone matures in three years. Because three years are required for cones to develop, an attempt to increase numbers of cones will not affect seed production until at least three years later (Little, 1938b). The first year must be especially suitable for production of large numbers of ovulate primordia, and the second and third years must be favorable to growth and maturation of cones and nuts (Little, 1938b). Nuts are generally produced at intervals of four to seven years.

As suggested by Little (1941), fertilization, cultivation, and irrigation might be used to

stimulate nut production. As shown in Schmidling's schematic, fertilization, especially with nitrate nitrogen, could increase flowering by producing high organic nitrogen levels in the trees. Cultivation and properly timed irrigations could increase the yearly moisture supply available to trees, thus increasing surface area of foliage, crown density, and carbohydrate reserves used for bud formation. An increase in crown density and foliage area may enable young trees to start bearing earlier, since it has been shown for other pines that flowering is related more to size than age (Schmidtling, 1969).

Selective thinning of unproductive trees, also suggested by Little (1940), should increase flowering of the remaining trees. Little (1940) mentioned that some trees are consistently good nut producers, while others are consistently poor. Productive trees usually show immature and old cones in branches, and an accumulation of fallen cones beneath them. Thinning will, therefore, have a two-fold effect: reduction in tree density, and increased nut production.

At the Mora Research Center, studies have begun on fruitfulness in pinyon. Some of the work has been done in natural stands, some will be performed in an experimental orchard of 72 trees (5-10 feet tall) established at the station.

In natural stands basal pruning to a height of five feet was applied to trees 70 to 80 years old with an average height of 25 feet. Ten trees were selected at random for basal pruning and ten trees left unpruned. Pruning was done in February of 1972, and the nut crop was evaluated in October of 1974.

Pruned trees consistently produced larger and heavier nuts. From pruned and unpruned trees, nuts weighed, respectively, 0.32, and 0.24 g, and had volumes of 0.40 and 2.32 cm^3. Although pruning failed to significantly increase shell-out, pruned trees produced a greater percentage of filled nuts, 99 percent as compared to 84 percent.

The effects observed were related to the effect of pruning on growth of nuts in cones already developing, since the study lasted only two years. Because of its simplicity, basal pruning may prove to be a valuable technique for stimulating nut production. An increase in nut size should definitely facilitate the laborous task of picking and shelling. Pruning could be done during thinning operations.

PINYON CHRISTMAS TREES

Pinyon Christmas trees are harvested from natural stands on federal, state, and private lands. In 1964, pinyons comprised 25 percent of all Christmas trees sold in the six-state-area of New Mexico, Arizona, Colorado, Wyoming, Utah, and Nevada (Sowder, 1965).

In reproduction and immature stages (Figure 2: Bradshaw and Reveal, 1943), pinyon trees possess many of the attributes of a Christmas tree:

1. dense foliage
2. symmetrical shape
3. green color
4. branch angle and limb strength suited for hanging pendulous ornaments
5. natural fragrance
6. good needle retention following harvest.

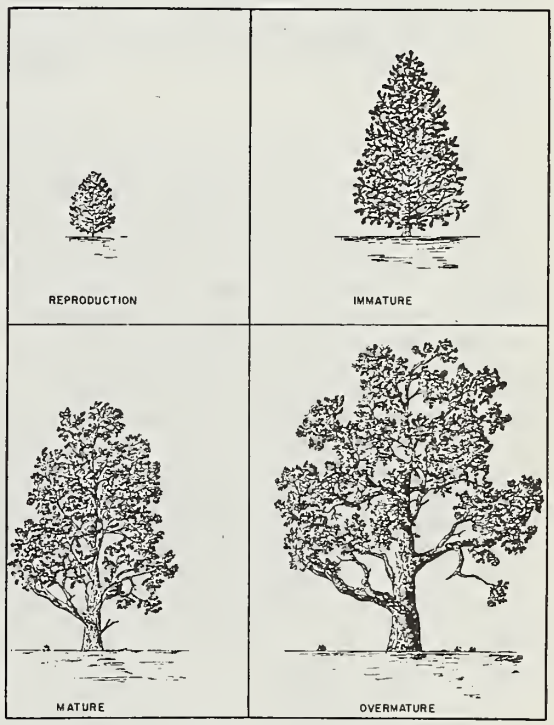

Fig. 2. Maturity classes proposed for Pinus monophylla (Bradshaw and Reveal, 1943)

However, demand for pinyon Christmas trees has declined since 1960 (Barger and Ffolliott, 1972). This may be due to increased competition from artificial and plantation-grown trees and from a reduced supply of marketable trees. Through proper management, pinyons growing on

moderately deep soils can be cultured into saleable Christmas trees, and cut on a rotational basis, if desired.

Cultural techniques include thinning, pruning and shearing, stump culture, and weed control (Jensen, 1972). If the management goal is complete conversion, then these techniques would be applied to trees surviving cabling or chaining. If the goal is to sustain tree production, then regeneration plantings would be needed. Containerized seedlings could be planted under nurse trees in the spring, as suggested by Jensen (1972).

Thinning involves removal of trees in dense stands so that those remaining will receive sufficient sunlight for limbs to develop uniformly on all sides. During thinning, "handles" can be made on main stems of trees by removing branches for a foot or so below what will be the crown base of the tree. These are cut below a full whorl of branches, leaving several branches at the base of the tree for stump culture subsequent to harvest. A year after the tree has been cut limbs begin to turn up and with the exception of one main stem are pruned.

The ideal Christmas tree resembles an inverted cone, wide at the base and tapered uniformly to the tip. Spruces and firs have an acceptable taper of 40 to 70 percent, while pines have a greater taper with an acceptable range from 40 to 90 percent. Pruning and shearing of pinyon trees in natural stands will make them conform more closely to the ideal, so they are competitive with artificial and plantation-grown trees. Pruning involves the removal of dead or defective branches to improve appearance of the tree. The aim of shearing is: to control leader growth so that the distance between shorls is not excessive; induce more branch buds to develop than normally do so; and give the tree the desired pyramidal shape. Because leader growth of pinyon trees rarely exceeds eight inches, excessive distance between whorls is not a problem. Uneven, ovoid, and thin crowns do occur and will benefit from pruning and shearing.

In pines each needle bundle contains a dormant or adventitious bud. If the terminal portion of the stems is sheared at the proper time of year, a number of dormant buds in needle bundles just below the cut will develop into short buds. The result is increased crown density. In single-needled conifers such as spruces, firs, and Douglas-firs, intermediate buds are produced along the terminal stems between each whorl. For this reason, they can be sheared during any season of the year and produce about the same number of branch buds.

In pines the number and size of the branch buds produced depends upon the physiological state of the tree when it is sheared. It is best to prune pines just after height growth has been completed, but before tissues in the stems have completely hardened. At this time the number of large, vigorous buds that develop below the pruning cut will be from two to four times as great as the number on unpruned stems. Pinyon shoots elongate principally during the last of June and continue to elongate during July and August after candle growth has ceased. Buds are formed in August and September.

Studies in South Dakota (Collins, 1960) and Colorado (Sprackling, 1968) related shearing date to bud formation in ponderosa pine. These showed that shearing should be done shortly after candle elongation is completed. The Colorado study further demonstrated that shearing should be done after current needles have grown to one-third full length, usually in early July. Also, trees pruned in late summer produced only a few buds so that growth and foliage density was less than that of unpruned trees. Shearing too early in the growing season is, therefore, preferable to shearing too late.

Although no shearing studies have been published on pinyon that we are aware of, certain general recommendations for shaping pinyon can be derived from the literature.

1. Prior to growing season, prune all double and multiple leaders. This could be done in April.

2. Shear when needles on new candles are 1/3 as long as last year's needles (usually from June 15 to July 1). Shear leader at a 45^{o} angle. Do not use a horizontal cut.

3. Shape the tree from the top down by shearing the tips of the laterals. Give the tree a conical shape so that the base is no more than 90 percent as wide as tall. Ideally, taper should be 40-90 percent. Avoid shearing back to woody tissue, since this may result in double or multiple leaders.

4. If the tree is oblong rather than tapered, shear the top in June or early July, and the sides in late summer, fall, or winter. Growth of laterals will be reduced. Steps 2-4 may be repeated annually as needed.

5. During final year of marketing, avoid shearing.

Because grading systems developed by the USDA emphasized the slender, tapered form of true firs and spruces, and degraded trees with more ovoid shapes, Kearns et al. (1962) prepared standards for pinyon Christmas trees.

Pinyon trees are found acceptable under this classification that would have been culled under USDA guidelines. Four form classes are recognized and are considered equally acceptable:

1. tapered
2. triangular
3. oblong
4. round

Within each class, trees may be graded on the bases of color, density, symmetry, and deformity. A premium tree has dense foliage, four good sides, deep green color and possibly a minor deformity; a standard tree has less dense foliage, three good sides, and minor deformity; a utility has only two good sides, generally more open foliage, minor deformity, and possibly some loss of color. Culls do not meet minimal requirements of any of these categories.

PINYON NURSERY STOCK

As discussed earlier, cabling and chaining do not effectively kill trees less than 10 feet tall. Reproduction and immature trees are ideal for nursery stock. Where soils are deep, free of large rocks, and not easily eroded, trees can be dug and sold to offset, somewhat, the costs of conversion.

Pinyon trees can be dug when dormant, usually from late September to April in most areas. The most popular size for large transplants is 6-8 feet, since special equipment is not needed to handle the root ball.

For trees growing on porous soils, digging should be scheduled during months when soil moisture is sufficient to hold root balls together. If this cannot be done it may be necessary to water trees artifically.

Several measures may be taken to improve the quality of trees to be sold and to improve post-transplant survival. Thinning of unwanted trees and weed control will release desirable trees to develop symmetrically. Pruning and shearing can be employed in the same way as that used for producing Christmas trees. Trees that have been knocked down by cabling, but have survived, may be especially appealing after they are pruned to resemble wind-swept trees.

Techniques to increase post-transplanting survival are rarely used, but are highly desirable. Root pruning a year in advance of digging may increase survival. Spraying the foliage with antitranspirants before digging may also help.

Discussions with numerous nurserymen about their tree digging practices have made apparent the need for stronger measures to prevent the spread of pinyon insects and diseases infesting transplants. Very few diggers consult with plant inspectors, forest rangers, or county extension agents before moving trees. Certainly, there is a need to educate these individuals about the serious problems that may arise from transporting infested trees. Of course, transporting infested trees across interstate lines is illegal, and plant inspectors confiscate and destroy truckloads of trees when disease and insects are detected. This type of loss can be avoided as digging crews could identify infested trees.

Transport of infested trees can greatly expand the range of the pathogen and insect pests. For example, the pinyon pine dwarf mistletoe (*Arceuthobium divaricatum*) was moved two hundred miles north of its previous range when pinyon from New Mexico were transported to Colorado.

Management of pinyon stands to keep harmful insect populations at low levels is difficult, primarily because it is difficult to spray the trees with ground rigs. For small acreages the backpack sprayer is economical and efficient. On large acreages an economical method to manage insect pests is to cut down infested trees and use them as fuelwood.

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Forest Practices Needed for the Pinyon-Juniper Type

Raymond R. Gallegos[1]

Thank you Mr. Chairman, Fellow Members of the Society.

One of the highest honors to ever come my way was on January 1 of this year, when the Executive Vice-President of the Society of American Foresters, Mr. Glascock, wrote me to advise me that the council had approved my application for membership in the Society of American Foresters. This is an honor I have looked forward to for the past 15 years.

Although my formal education is not in the field of Forestry, I feel that since I have dedicated 15 years of my life to this great profession, that I am deep rooted and very gladly so. In this context, the one thing that stands out is that foresters, those individuals who have dedicated their lives to the conservation of our timber resources, are men of integrity. They are individuals who are sincere, honest, and who are willing to give total support to their profession.

Thankful and honored am I, of being a small part of this Society. Individuals - professional foresters - such as, Jean Hassell, Yale Weinstein, Erb Kalusa, Tom Borden, Tom Schmeckpeper, Mel Hyatt and countless others, are some of the individuals I work with, and I find that these professionals give 120 percent of their knowledge and of their compassion to help you and I, as individuals, or as a group.

ARE FOREST PRACTICES NEEDED FOR THE PINYON-JUNIPER TYPE?

This is my subject matter for today. To answer this question honestly, sincerely and completely, one must surely explore the benefits that can be derived from this type.

In talking to different individual foresters, many of whom are in this very room, I was not able to get a definite, concrete answer. Many of those individuals support one school of thought, in which they tend to support the eradication of Pinyon-Juniper in support of best range management practices. Then, we have the other school of thought, and that is that Pinyon-Juniper should be left intact, and that stands of Juniper should be properly managed under the best forest management practices.

But, the thing I keep hearing most is "There is not that much information, or studies conducted as to a potential market for Pinyon-Juniper." All of the studies on the Pinyon-Juniper type are in their infancy. There just has not been that much time, effort, or money put into exploring the possibilities of this type.

It is generally accepted that, of the two classifications, commercial and non-commercial, that Pinyon-Juniper falls under the category of non-commercial, and as a result will also take on a further classification of "little value."

In view of this, one could very easily assume, that possibly, the best and only logical way to go would be to eradicate the Pinyon-Juniper type and use these lands for other purposes; namely grazing.

Possibly, the things I want to bring out to you and what follows, may seem rather basic to many of the people here today; however, my approach to this subject was brought about by analyzing "what are the every day problems" and questions that State Forestry personnel deal with in advising private landowners. We must realize that the average citizen is concerned with what is at hand, and one thing for sure, is that small landowners do not want to put too much money into improvements. Why? Simply because they cannot afford it. Their main interest is to learn how to get the most out of their land, without having to put in any more money, or having to wait 5 to 10 years to recover their investment.

So, let's hold on for a minute and explore some of the goods that we do know have come out of this type in the past. What is evident, and what are the known facts that we can come up with to support the continued existence of the Pinyon-Juniper.

For one, the market for Pinyon Nuts is steadily gaining momentum. Just the other day, I walked into a store in downtown Santa Fe to purchase a pound of Pinyon and I was almost

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[1]State Forester, New Mexico Department of State Forestry. Santa Fe, New Mexico

floored when the clerk charged me $3.39 a pound. Knowing the clerk real well, I asked him, "Isn't this rather high for Pinyon?" The clerk advised me that the demand was so high, that he was purchasing in bulk, because by purchasing in bulk, he was able to give his customers a better price.

He went on to say that many of the stores in Santa Fe were selling the Pinyon Nuts at $4.00 a pound. I was not satisfied with just the one source, so a further investigation produced the following:

2nd Retail Source - $3.25 a pound

3rd Retail Source - $3.49 a pound

4th Retail Source - $3.75 a pound (Roasted)

5th Retail Source - $7.60 a pound (Roasted and Peeled)

Of course, the last source is not a comparable source, but who would ever dream that a pound of Pinyon could bring in $7.60 a pound. Surely, if the demand for the Pinyon Nut is increasing to such an extent that the retail price is now approaching $4.00 a pound, then let's again stop and analyze what the Pinyon crop could bring to our economy.

For instance, one of the largest harvests on record was in 1936, when eight (8) million pounds were gathered in New Mexico, and the estimated revenue was $700,000. To calculate what it would bring at today's prices (at $3.50 per pound), would amount to a total of 28 million dollars. Now, we know that the average gathered per year is not eight million pounds, but the average gather per year is estimated at one and a half million pounds. Even at this, it would mean (at $3.50 per pound), that it would bring in $5,250,000 in revenue to Pinyon pickers and processors.

With this much potential revenue in the sale of Pinyon Nuts, one surely must consider this as a factor in favoring a need for forest practices on the Pinyon type.

Also, we find that in Utah alone, approximately 40,000 Pinyon trees are used annually for Christmas Trees. Statistics indicate that there are approximately 60 to 75 million acres of Pinyon-Juniper in a five state area, and those states are Nevada, Utah, Colorado, New Mexico and Arizona. Statistics also indicate that New Mexico and Arizona have at least one half of those acres. One can just imagine the potential available to these two States in the promotion of Pinyon as a Christmas Tree. Also, along with the number, or demand needed, one must also consider the going rate. The last figure I was able to obtain is that a Christmas Tree has been selling for between $2.00 and $3.00 per foot. Let's add another plus in support of proper forest management of the Pinyon type.

Firewood.- I venture to say that 80 to 90 percent of the people in this room have had the experience, or have heard a neighbor or friend complain of the high prices they have been paying for a cord of firewood. The latest figure I was able to obtain is that firewood is selling for between $50.00 to $70.00 a cord.

Virtually every home being built today has a fireplace, and with the ever increasing problem that we are facing in the energy crisis, it is a sure thing, and it is also safe to say that the demand for firewood is increasing in leaps and bounds. Again, I feel very strongly that we should add another plus for proper forest management of the Pinyon-Juniper type.

How about Juniper fence posts? The latest information on this is that they usually start at about $1.50 and some of the better posts are selling for as high as $3.00 each. Many thousands of miles of fence line are being put up annually and, in many instances, the posts used for the fences are Juniper posts. Does this market not deserve at least a small plus in defense of proper forest management of the Juniper type?

Another very important aspect that, surely, has to be considered in the Pinyon-Juniper ecosystem is wildlife. How many hundreds of different species of both small and large mammals and birds make their homes in this system?

There does not seem to be a definite answer to this, as some of the research material will tend to lead you in a certain direction. Then, one reads other material which will state just the opposite. For example, here is a quotation that I would like to read to you, and I quote, "Of the many species of wildlife that inhabit the Pinyon-Juniper ecosystem, all or part of the year, few species are considered to be obligate." Another piece of research material stated, and again I quote, "We remain in near total ignorance of the impact of Pinyon-Juniper conversion on the hundreds of vertebrate species influenced by this large ecosystem."

If there is this much uncertainty as to what species do exist and the effect it would have on them, should the system be eradicated? Should we not be real concerned about the wildlife that cannot exist outside this system? And then again, even "IF" and this is a big "IF," the

majority of the wildlife could survive outside the Pinyon-Juniper type, why should we pass rules and regulations to drive wildlife away from a habitat that is native to them?

The point that I want to bring out here is that the Pinyon-Juniper does, in fact, provide food and shelter for many species of wildlife. Simply because some evidence points out that there is a possibility that many species of wildlife can survive in other environments, is not sufficient reason to consider eradication of the type. The Pinyon-Juniper system for many animals and birds is the ideal habitat, let's find ways to satisfy both man and beast.

Another consideration that must be dealt with here, is that of the Endangered Species Act. This act has come about and the rules that govern this are very enforceable, with strong legislative support.

Wildlife must be, it has to be, a serious consideration and the thought of favoring eradication without regard to wildlife would, undoubtedly, be a very serious misjudgement.

In my research for the preparation of this talk, I contacted several officials of the State Game and Fish Department. Their concern, as would be expected, is that proper management be applied. They went on to say that if the stands are, in fact, too dense, sure, open them up for better wildlife utilization, but this does not go to say that they would support complete eradication of large areas of Pinyon-Juniper type.

Many of those game officials also went on to say that the Deer population does, indeed, depend on Pinyon-Juniper and should programs or management plans come about to eradicate large portions or sections of the Pinyon-Juniper type, all of the wildlife that use this type as their habitat would, indeed, be affected.

So, again, all indications in dealing with wildlife living within this ecosystem tend to strongly consider stepping up the process for providing best forest management practices for the Pinyon-Juniper type.

Another approach that I would like to bring out to you for your consideration is, let's examine the signs which indicate a definite need for wood products in the future. One can pick up a newspaper, or sit down to watch television, or turn on the radio, be it at home or in our cars, and what is one of the subjects constantly being discussed? Energy, is it not? This subject is not being discussed only locally, but throughout the entire world. "People are very concerned." The leaders of all nations are being pressured to enact legislation to support new programs for the development of new and better ways to produce one of our most precious commodities - "energy."

Our forests may possibly supply a portion of that precious commodity. There have been some studies conducted along these avenues, yet, studies and pilot programs are barely scratching the surface. However, one thing that is certain is that the demand for renewable resources is getting greater and will continue along these trends with the ever increasing population growth.

Population growth, as is evident, results in the depletion of both our renewable and non-renewable resources. Do we have an answer to produce non-renewable resources? Of course not, so we must rely heavily on our renewable resources. We as foresters, must explore and come up with the necessary guarantee that our nation and all nations of the world are continually supplied with wood and wood fiber, a resource that is renewable and one that should be made available upon demand.

I came across the Dr. Jean Mater paper which dealt with the feasibility study for utilizing sawmill and forest wood residues for the generation of electric power. The results of this study were published in October of 1972, yet to my knowledge, very little action has been taken on the recommendations that were proposed which, in part, are as follows, and I quote, "Our investigation of the feasibility of utilizing wood and bark residues available in North Central New Mexico which will produce electric power, leads us to believe that this is an excellent method of solving two regional problems. Namely, (1) air pollution and (2) energy shortage. We recommend that the regional authority pursue the investigation with a determination to build a power plant, that is, if the conclusions of this preliminary study are confirmed."

Evidently, there is a "bottleneck" that has held up the progress of the forward movement of the construction of the plant, I venture to say a lack of support in obtaining adequate funding. The essential point, however, is that research is underway. New and better methods for the utilization of our wood products will come about.

Demand - can we meet the demand? The emphasis has been in disregarding the Pinyon-Juniper type for other forest types that will produce more lumber and, thus, a greater return for the money invested. Definitely, good common sense will guide us toward this end. But, are we going to be able to completely satisfy our needs in the future by only caring for those types that produce the greater return, or are we going to be caught short? I don't know the

answer to this and, in my opinion, I do not believe that there is any one else who has a correct, absolute, definite answer.

Then, doesn't it stand to reason that we should start preparing ourselves to be able to meet the demands of the people, the demands of the nation, in the best way we know how. Who has the responsibility to assure that the supply will meet the demand? Does it not rest on our shoulders?

The question is, how do we accomplish this, by complete eradication of the Pinyon-Juniper type, or by bringing about best forest management practices.

Managing Pinyon-Juniper for Multiple Benefits

William D. Hurst[1]

The 60 million acres of pinyon-juniper in the Western United States has throughout the years provided numerous benefits to people, both local and to those who live some distance from where these pygmy forests grow. It can be accurately said, I believe, that in the settlement and development of the West, products and benefits from the pinyon-juniper complex played a more significant role than did the so-called commercial forest type.

Fuel

The pinyon-juniper type provided heating and cooking fuel for thousands of homes and was the only source of fuel for many of them. For better than half of my life, pinyon-juniper has provided the heating and cooking fuel used in my family. Even today, this species fuels many homes in the rural areas of the western states, and its use is very likely to become more prevalent.

Posts

The "cedar" post fenced the West, and this post is yet the most common on the fence lines of western America. You can prove this to yourself by observing the fence line of the highways and byways of western America.

Forage

The pinyon-juniper type furnishes an extremely important part of the total years supply of forage used by the western livestock industry. The so-called spring-fall range is largely confined to this type and is used about 6 months each year, sometimes more. The type is also the critical winter range for many deer and elk herds and provides a rich environment for many species of wildlife.

Charcoal

Pinyon was the foundation of a substantial charcoal industry in many parts of the west. Thousands of acres were heavily cut to support this business.

Christmas trees

For many people, there is no true Christmas without a pinyon or juniper Christmas tree. Their popularity is growing.

Nuts

Pinyon nuts have been a staple food for Indian people from time immemorial and a delicacy for the white man. They are nutritious and delicious and in demand. Their popularity is growing.

Archeological

Because of its altitudinal and longitudinal location, between 4500 and 7500 feet above sea level, the pinyon-juniper type has been a very hospitable living area since the advent of man. Because of this, pinyon juniper stands are rich in archeological treasures--a value not adequately recognized.

Medicinal

Both pinyon and juniper contain medicinal properties that are very valuable. Although not economically feasible to extract at the present time, they may be competitive in the future.

Pulp

The pulping qualities of pinyon are acceptable but not competitive with other species at present. Both species hold promise for such use in the future.

Naval Stores

Pinyon contains the potential for naval store production but again is not yet competitive.

Ornamentals

The pinyon pine is widely used as an ornamental and this use is increasing.

Fifteen percent of pinyon-juniper type or about 9 million acres is on the National Forests. Of this acreage, the Forest Service estimates that about 2 million acres is on soil types that would respond to thinning or clearing

[1]Retired, Regional Forester, USDA, Forest Service, Albuquerque, New Mexico

effort, primarily to improve forage for livestock and big game. Of this 2 million acres, about 700,000 has been treated in one way or another. I cite these figures because the ratio is likely similar on BLM, state and private land. Not a large percentage of the pinyon-juniper complex lends itself to type conversion.

Both species, pinyon and juniper, are aggressive invaders when man or nature reduces competition on areas adjacent to the pinyon-juniper's natural environment (cite the 1921-1941 and 1958 Grantsville studies). Because of overgrazing and a rigid fire control program, pinyon-juniper stands have "thickened up" in many places.

It is my personal feelings that control of these species should be confined to areas of invasion. These are usually the deep and productive soils where the sought after objectives are most likely to be achieved. Simply because an area would produce more forage if the trees were thinned or removed is not the sole or even the most important criteria for taking such action. A careful multi-disciplinary process is required.

Control or conversion work is usually undertaken in the pinyon-juniper type for four purposes: (1) to increase forage for domestic livestock, (2) to improve watershed conditions, (3) to increase water yield, or (4) to improve wildlife habitat. Most often, increasing forage for livestock use is the initiating force.

When resource conditions and land use objectives indicate the feasibility of pinyon-juniper control, an evaluation or planning process begins. An inventory of vegetation, soils, water, wildlife, archeology, and other resources is developed, coordinated, and evaluated in an environmental analysis. Effort is made to involve throughout the process livestock operators, state game and fish department personnel, public interest groups, and other interested agencies and people. The findings of the environmental analysis and the public reaction to it forms the basis for a decision to proceed or not.

Experience has shown that forage increases in economic amounts can be achieved only on the deeper soils that have been invaded by either pinyon or juniper or both. Areas having a tree density of less than 120 per acre are not treated. Areas having 250 trees or more per acre usually have the greatest chance of becoming a profitable operation.

If increased forage production is the objective, a soil depth of at least 20 inches is required. The more shallow, rocky soils favor browse, and browse will come back if the pinyon-juniper is removed. Sandy soils should be avoided when mechanical treatment is applied unless sufficient debris is left on the ground to form a protective mulch. Slopes exceeding 20 percent should not be treated. The grass and browse species seeded should either be native to the area or of proven adaptability.

Research in Arizona has shown that, under most conditions, little benefit can be obtained by removing or controlling pinyon-juniper to improve water yield. The practice is, in my opinion, not justified economically or environmentally for this purpose. Without doubt water yield can be improved in some areas if the overstory is removed but the benefits are small. The cost cannot be justified for water yield alone. Some very limited areas may be exceptions to this rule, but they are indeed scarce.

From the standpoint of wildlife, it goes without saying that what is good for one animal species is not necessarily beneficial to another. When tree numbers exceed 150 per acre, there is usually a noticeable reduction in understory shrubs. When this occurs, an important food source for deer and elk is adversely affected. The pinyon-juniper type is very important as winter range for these animals, and a reduced food supply at this time of year can be critical for them. Where control or treatment is undertaken, patterns should be carefully planned to create uneven margins and optimum "edge" islands and fingers of unmolested cover must be provided for shelter and escape routes.

The economics of pinyon-juniper control has been the subject of many arguments. In the Southwestern Region of the Forest Service, costs have averaged 25 to 27 dollars per acre for a completed job using the tree crusher; this cost includes seed for reseeding. Chaining costs may be a dollar or two less, but by the time the necessary cleanup and seeding have been accomplished, the difference between the two methods will not be great. There are two other major methods of control--burning and use of chemicals but these two methods have not been used much in the Southwest because hot fires are hard to control, and if they aren't hot not many of the trees will be burned. Chemicals can be effectively used in initial control of pinyon-juniper, but because of widespread public opposition, they have seen little use.

USDA, Forest Research Paper (RM-128) of October 1974 includes an economic analysis of pinyon-juniper control work on Beaver Creek south of Flagstaff, Arizona. This study shows that a successful pinyon-juniper control project

should expect an increase in usable forage of 400 to 600 pounds per acre beginning 2 or 3 years after treatment. An average increase of 500 pounds per acre is equivalent to 0.27 AUM's per acre. Using $5.82 per AUM capitalized at 7 percent interest, the benefit from the project was $19.15 per acre. Additional benefits from reduced labor costs and faster weight gains of yearling calves were $4.33 per acre, making total benefits to the project of $23.49 per acre. A quick comparison shows that for even the more successful projects, the margin between benefits and costs is close. Consequently, each project must be examined carefully on its own merits.

The same study concluded that mechanical methods of pinyon-juniper removal are not likely to increase water yield, change peak flows, or change water quality. It also concludes that herbage growth increased following virtually all pinyon-juniper treatment efforts, although there was a great variation in the amount of herbage produced. This study also indicated that response by deer to the Beaver Creek work was neutral.

What of the future of the pinyon-juniper ecosystem? Perhaps no vegetative type has given man so much and been so harshly treated and neglected. Management of the type, with the perpetuation of pinyon-juniper is yet nonexistent. While a small portion of the 60 million acres of pinyon-juniper on the most productive soils can and should be changed to grassland or browse since these lands are extremely productive for forage species, the original stands can best serve man if managed to maintain and encourage pinyon and juniper. If properly managed, these lands can produce substantial volumes of forage while providing many other benefits to man. In fact, no other vegetative type lends itself so well to multiple product management--forage, posts, Christmas trees, nuts, fuel, wildlife habitat.

Perhaps most important of all, the pinyon-juniper type is an attractive part of the western landscape. For this reason alone, it should be perpetuated. Moreover, it is extremely productive and the value of its numerous products need greater recognition.

With a new nursery going up in the Southwest, perhaps greater efforts can be made to manage pinyon-juniper on a substantial scale. I would hope that areas could be set aside, planted and managed for, as a beginning, posts, Christmas trees and nuts.

Systems Approach to Pinyon-Juniper Management

Gene Anderson[1]

Thank you for the opportunity to speak to you today. As stated by Mr. Kolusa, I am replacing Mr. Cary W. Hull on the agenda.

I am new in this area, having newly arrived from California in January. I am quickly learning about P-J management however, and listening to the speakers yesterday has certainly increased my accumulated knowledge.

The systems approach to P-J management is really just an approach which translates the information that we have been sharing these 2 days into language that the average landowner can understand and use. I believe that we have much more information than we realize, if we can only manage to get it into terms for private landowners. As professionals, we sometimes belittle the information that we have. But when we translate it to the public, you would be amazed at how much it seems to be.

Many of you may not be in the position of working with private landowners, so this discussion may seem odd to you; but, P-J management cannot be done on government-owned land alone, and it certainly cannot be done without the public's cooperation.

A management systems approach breaks the problem down into simple terms. In this case we can use three: (1) erosion control, (2) forest management, (3) grazing management.

In the Soil Conservation Service, we stress soil management as a key to using and maintaining all of our resources. The soil management system which can consist of erosion control and maintenance of the litter layer, is an excellent starting point for educating the public as to the importance and complexity of the pinyon juniper community.

The second system, forest management, is a natural, as most landowners are most interested in what to do about those darn trees. We address the subject, but again, we stress the relationship to soil management. Many P-J soils will not respond well to clearing or even heavy thinning, so we built this system on what we learned in designing the first.

The third system, grazing management, may be the most important to some people, but must be handled within the confines of the other two on true woodland soils. As we have seen these last 2 days, the whole resource can be ruined if we allow this system to over-ride the other two.

What is a "Systems Approach?" It boils down to a complete management plan based on research, common sense, and a thorough understanding with the landowner. Using a method such as this that totally involves the landowner is the only way that we will get P-J management on the ground.

Thank you for the opportunity for me to speak to you, I hope to work with you all again in the future.

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[1]Soil Conservation Service, Denver, Colorado

☆U.S. Government Printing Office: 1977-782-128/197 Region 8

Aldon, Earl F., and Thomas J. Loring, tech. coord. 1977. Ecology, uses, and management of pinyon-juniper woodlands: Proceedings of the workshop. [Albuquerque, N. M., Mar. 24-25, 1977.] USDA For. Serv. Gen. Tech. Rep. RM-39, 48 p. Rocky Mt. For. and Range Exp. Stn., Fort Collins, Colo. 80521.

It is estimated the pinyon-juniper woodland type occupies 33 million acres in the western United States. This vast resource has great potential for social benefits. Our knowledge of the type is summarized in 12 papers in three areas: Ecology of the type, uses and potentials, and management strategies for the woodland zone.

Keywords: Pinyon-juniper, forest utilization

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